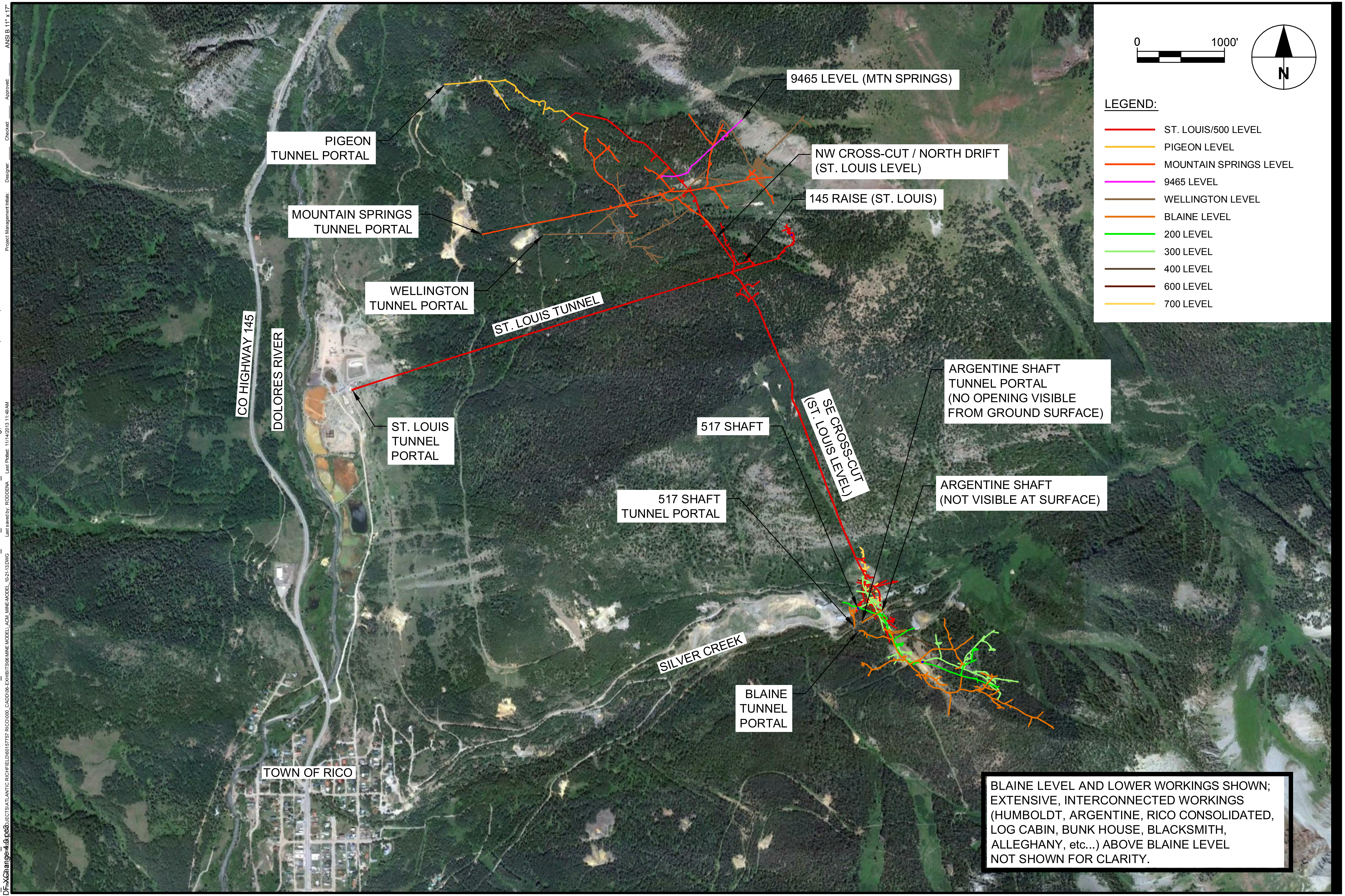
1290046

## ATTACHMENT 1

AECOM Mine Workings Figures




AECOM
MAY 29, 2012
60239806

# RICO-ARGENTINE SITE-OU01

MINE WATER MODEL PLAN OVERVIEW

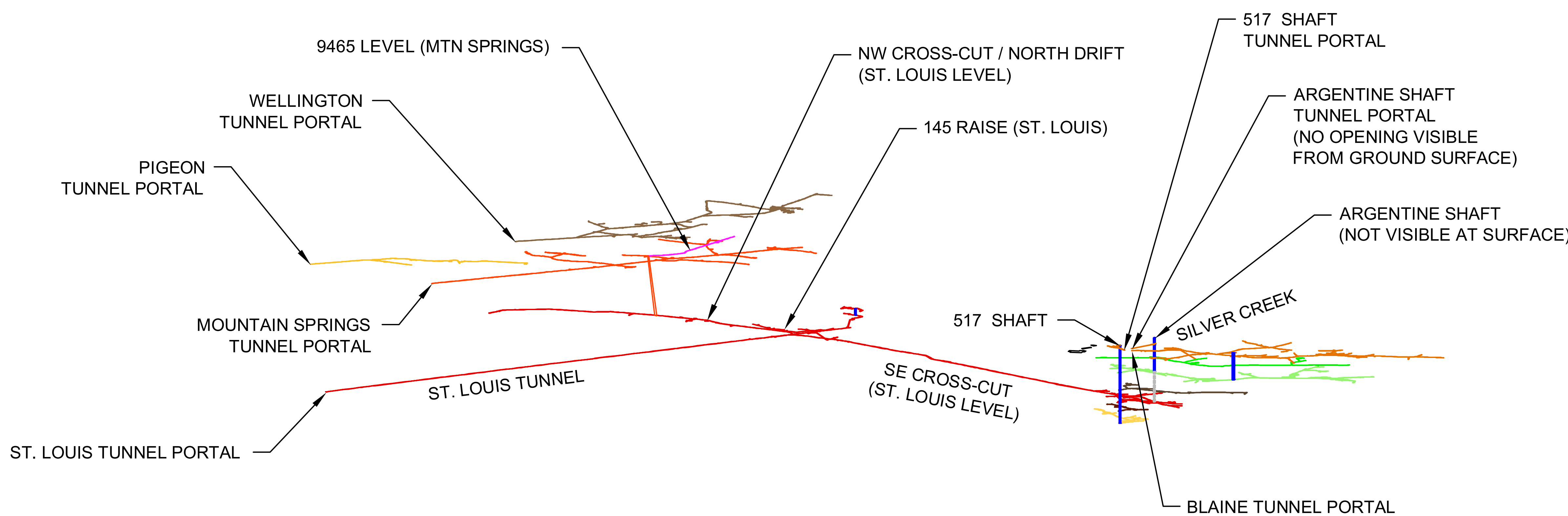
FIGURE 1

NOTES:

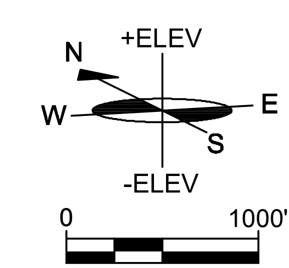
1. ALL MINE WORKINGS TRACED FROM "comp_Plan.tif", MAP #77 OF AECOM IMAGE INVENTORY, EXCEPT THE FOLLOWING:
   A. ARGENTINE SHAFT TUNNEL PER MAP #2, "scan02.tif", OF AECOM IMAGE INVENTORY. ("ARGENTINE MINE AND ST. LOUIS TUNNEL", DRAWN 5-21-55, P.L.J.)
   B. 517 SHAFT PER MAP #8, "scan08.tif", OF AECOM IMAGE INVENTORY. ("USGS/McKNIGHT PROFESSIONAL PAPER 723, PLATE 3")
   C. SILVER CREEK, BRIDGES & BUILDING FOOTPRINTS AT ARGENTINE TAILINGS PER ANDERSON ENGINEERING GROUND SURVEY, DATED AUGUST 2, 2011.
   D. ST. LOUIS SOUTHEAST CROSS CUT PER MAP #57, "00120110602202157.PDF", OF AECOM IMAGE INVENTORY. ("ST. LOUIS LEVEL, SHEET No. 2", DATED DEC. 1959 BY RT)
2. ALL LOCATIONS/DIMENSIONS APPROXIMATE ONLY.
3. ALL MINE LEVELS SHOWN AT SINGLE ELEVATION AND SEPARATED VERTICALLY PER USGS/McKNIGHT PROFESSIONAL PAPER 723 EXCEPT FOR LEVEL 700, WHICH IS SHOWN 100-FT BELOW 600 LEVEL.
4. NO EVIDENCE FOUND TO DATE ON HISTORIC MINE MAPS OF 517 SHAFT EXTENDING TO GROUND SURFACE.
5. ONLY SUGGESTIONS THAT ARGENTINE SHAFT EXTENDS BELOW 300 LEVEL ARE ON USGS/McKNIGHT PROFESSIONAL PAPER 723, PLATE 3, NOTATION ON MAP F (400 LEVEL) & MAP G (500 LEVEL): "ARGENTINE SHAFT (PROJECTED)". NOT SHOWN AT ALL ON MAP H (600 LEVEL); AND ON "ST. LOUIS LEVEL, SHEET No. 2", DATED DEC. 1959 BY RT.
6. FULL EXTENTS OF SOME LEVELS NOT SHOWN.

LEGEND:

- ST. LOUIS/500 LEVEL
- PIGEON LEVEL
- MOUNTAIN SPRINGS LEVEL
- 9465 LEVEL
- WELLINGTON LEVEL
- BLAINE LEVEL
- 200 LEVEL
- 300 LEVEL
- 400 LEVEL
- 600 LEVEL
- 700 LEVEL




BLAINE LEVEL AND LOWER WORKINGS SHOWN; EXTENSIVE, INTERCONNECTED WORKINGS (HUMBOLDT, ARGENTINE, RICO CONSOLIDATED, LOG CABIN, BUNK HOUSE, BLACKSMITH, ALLEGHANY, etc...) ABOVE BLAINE LEVEL NOT SHOWN FOR CLARITY.

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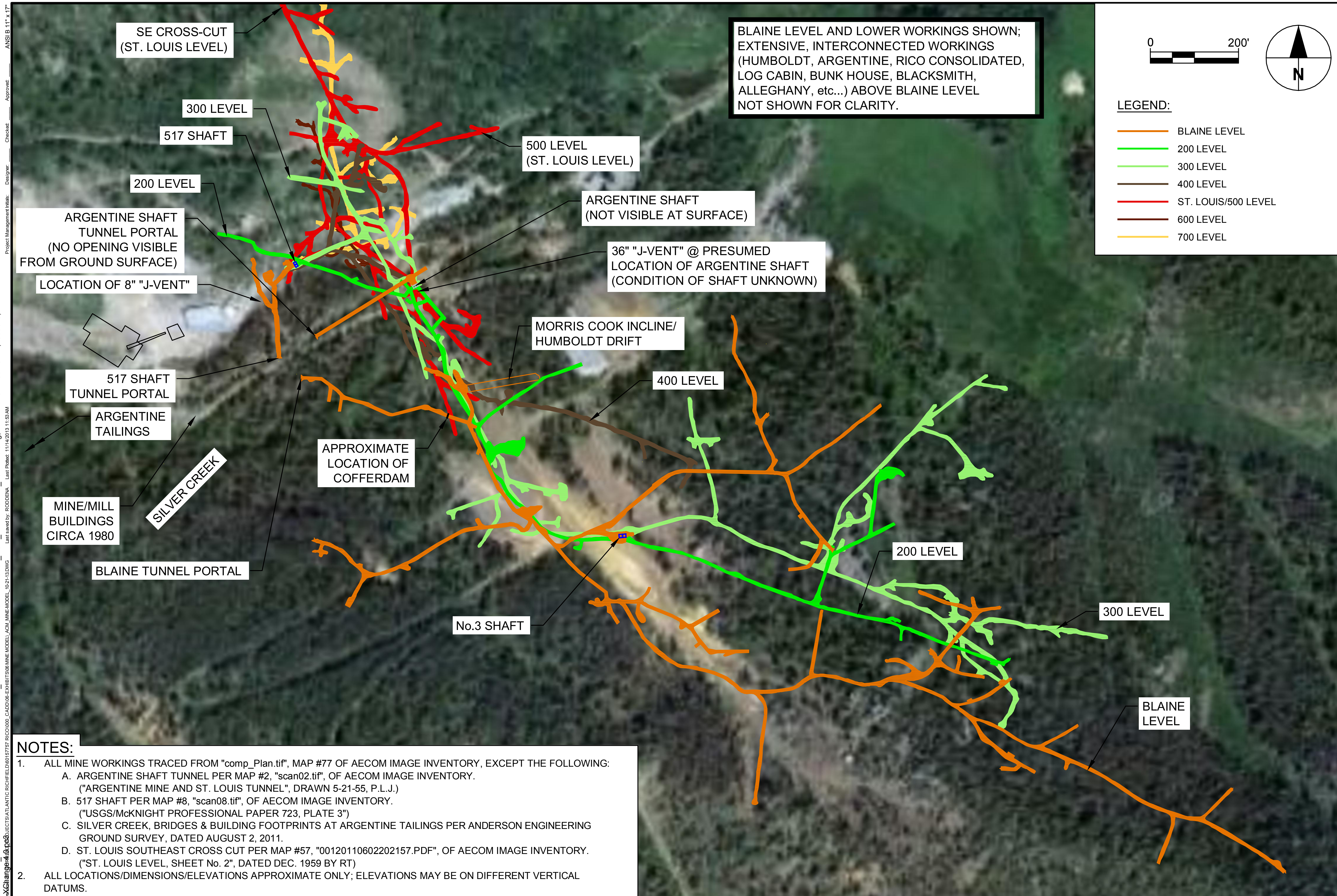
# RICO-ARGENTINE SITE-OU01

MINE WATER MODEL PERSPECTIVE OVERVIEW

FIGURE 2




NOTES:

1. ALL MINE WORKINGS TRACED FROM "comp_Plan.tif", MAP #77 OF AECOM IMAGE INVENTORY, EXCEPT THE FOLLOWING:
   - A. ARGENTINE SHAFT TUNNEL PER MAP #2, "scan02.tif", OF AECOM IMAGE INVENTORY. ("ARGENTINE MINE AND ST. LOUIS TUNNEL", DRAWN 5-21-55, P.L.J.)
   - B. 517 SHAFT PER MAP #8, "scan08.tif", OF AECOM IMAGE INVENTORY. ("USGS/McKNIGHT PROFESSIONAL PAPER 723, PLATE 3")
   - C. SILVER CREEK, BRIDGES & BUILDING FOOTPRINTS AT ARGENTINE TAILINGS PER ANDERSON ENGINEERING GROUND SURVEY, DATED AUGUST 2, 2011.
   - D. ST. LOUIS SOUTHEAST CROSS CUT PER MAP #57, "00120110602202157.PDF", OF AECOM IMAGE INVENTORY. ("ST. LOUIS LEVEL, SHEET No. 2", DATED DEC. 1959 BY RT)
2. ALL LOCATIONS/DIMENSIONS/ELEVATIONS APPROXIMATE ONLY; ELEVATIONS MAY BE ON DIFFERENT VERTICAL DATUMS.

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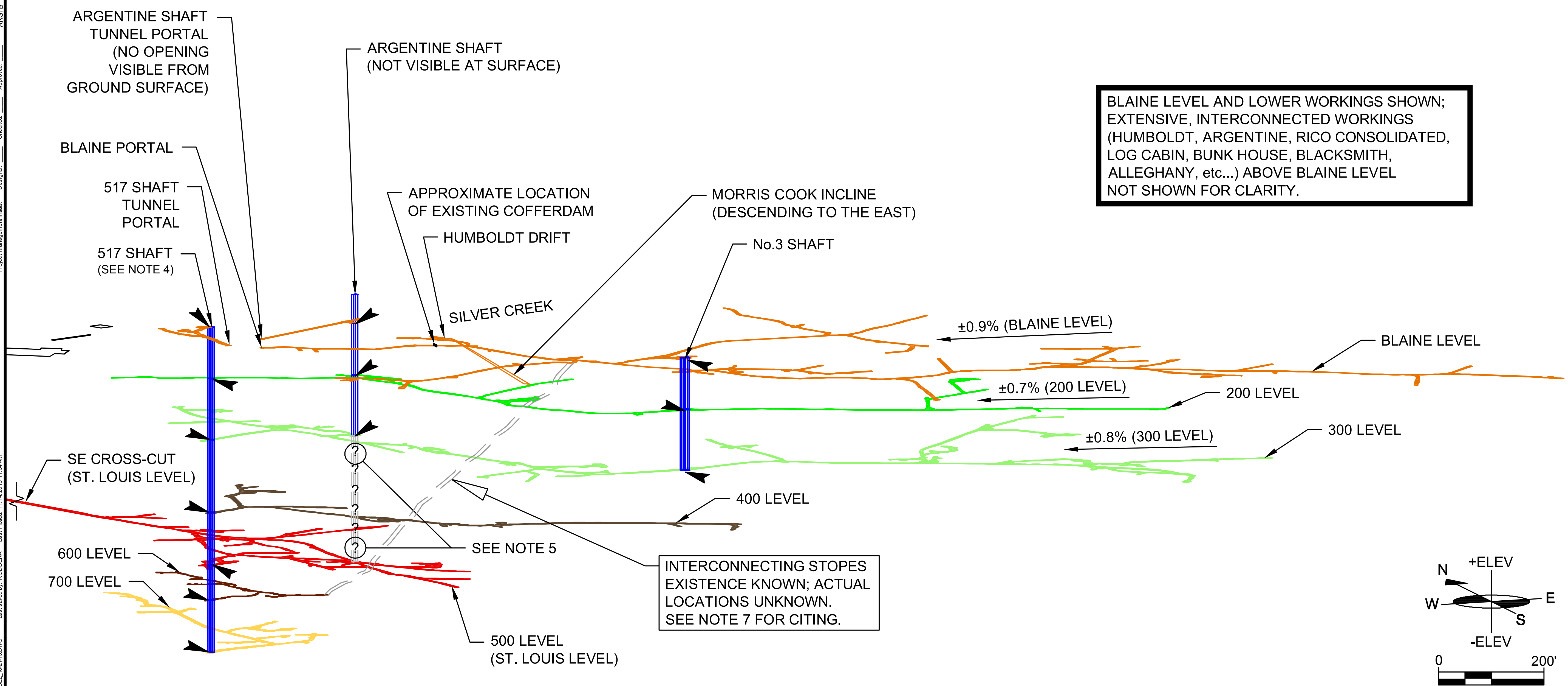
# RICO-ARGENTINE SITE-OU01

MINE WATER MODEL PLAN - BLAINE/ARGENTINE AREA

FIGURE 3




LEGEND:

- BLAINE LEVEL
- 200 LEVEL
- 300 LEVEL
- 400 LEVEL
- ST. LOUIS/500 LEVEL
- 600 LEVEL
- 700 LEVEL
- LEVEL CONNECTION W/ SHAFT
- LEVEL EXTENDS BEYOND

NOTES:

1. ALL MINE WORKINGS TRACED FROM "comp_Plan.tif", MAP #77 OF AECOM IMAGE INVENTORY, EXCEPT THE FOLLOWING:
   A. ARGENTINE SHAFT TUNNEL PER MAP #2, "scan02.tif", OF AECOM IMAGE INVENTORY. ("ARGENTINE MINE AND ST. LOUIS TUNNEL", DRAWN 5-21-55, P.L.J.)
   B. 517 SHAFT PER MAP #8, "scan08.tif", OF AECOM IMAGE INVENTORY. ("USGS/McKNIGHT PROFESSIONAL PAPER 723, PLATE 3")
   C. SILVER CREEK, BRIDGES & BUILDING FOOTPRINTS AT ARGENTINE TAILINGS PER ANDERSON ENGINEERING GROUND SURVEY, DATED AUGUST 2, 2011.
   D. ST. LOUIS SOUTHEAST CROSS CUT PER MAP #57, "00120110602202157.PDF", OF AECOM IMAGE INVENTORY. ("ST. LOUIS LEVEL, SHEET No. 2", DATED DEC. 1959 BY RT)
2. ALL LOCATIONS/DIMENSIONS APPROXIMATE ONLY.
3. ALL MINE LEVELS SHOWN AT SINGLE ELEVATION AND SEPARATED VERTICALLY PER USGS/McKNIGHT PROFESSIONAL PAPER 723 EXCEPT FOR LEVEL 700, WHICH IS SHOWN 100-FT BELOW 600 LEVEL.
4. NO EVIDENCE FOUND TO DATE ON HISTORIC MINE MAPS OF 517 SHAFT EXTENDING TO GROUND SURFACE.
5. ONLY SUGGESTIONS THAT ARGENTINE SHAFT EXTENDS BELOW 300 LEVEL ARE ON USGS/McKNIGHT PROFESSIONAL PAPER 723, PLATE 3, NOTATION ON MAP F (400 LEVEL) & MAP G (500 LEVEL): "ARGENTINE SHAFT (PROJECTED)". NOT SHOWN AT ALL ON MAP H (600 LEVEL); AND ON "ST. LOUIS LEVEL, SHEET No. 2", DATED DEC. 1959 BY RT.
6. FULL EXTENTS OF SOME LEVELS NOT SHOWN.
7. REFERENCE TO EXISTING INTERCONNECTING STOPES FOUND IN USGS/McKNIGHT PROFESSIONAL PAPER 723, FROM BLAINE LEVEL TO 600 LEVEL AND ON PAGE 85, "STOPE ABOVE BLAINE TO BELOW 200, I-J BED"; AND SHOWN IN SECTION ON MAP #74, "5-369.tif", OF AECOM IMAGE INVENTORY, ONE STOPE FROM BLAINE LEVEL TO 300 LEVEL AND ANOTHER STOPE FROM BLAINE LEVEL AND ST. LOUIS/500 LEVEL.

AECOM
MAY 29, 2012
60239806

# RICO-ARGENTINE SITE-OU01

MINE WATER MODEL PERSPECTIVE - BLAINE/ARGENTINE AREA

FIGURE 4

## ATTACHMENT 2

Historical Documents

# RICO ARGENTINE MINING CO.

AREA CODE 303-967-2281

P.O. BOX 158

RICO, COLORADO 81332

December 12, 1977

Mr. Irwin L. Dickstein
Director Enforcement Division
United States Environmental Protection Agency
1860 Lincoln Street
Denver, Colorado 80203

Ref: 8E-PC

Dear Mr. Dickstein;

We have taken measures to eliminate the Blaine Tunnel discharge (NPDES permit CO-0029793-001). The discharge was diverted underground to be discharged with the St. Louis water which discharge is processed by our series - decantation ponds. Samples of the discharge (002) have been taken but the results from Commercial Testing and Enginnering Company have not been received as yet to determine our net results.

Until recently we have not been plagued as to our discharge. Mining out of the Blaine Tunnel has not been in operation for seven years. The only explanation I can give is our lack of moisture, which in turn has eliminated the dilution factor of our mine discharge.

As of November 21, 1977 the Blain Discharge is none and will remain so until the mine is again reactivated; however, we do wish to hold our discharge permit 001.

I trust this will answer your immediate questions.

Very truly yours,

O. L. Jahnke

O. L. Jahnke
General Manager

OLJ:mj
cc: Mr. Frank Rozich
Mr. Gregory Hobbs
Mr. Mike Howell
Mr. Norman Palermo

RICO ARGENTINE MINING CO.

AREA CODE 303-967-2281

P.O. BOX 158

RICO, COLORADO 81332

August 25, 1980

Mr. Jack R. Whyte
Health, Safety & Envir.
Anaconda Company
555 Seventeenth St.
Denver, Colorado 80217

Dear Mr. Whyte;

The water samples were taken and sent to Commercial Testing, as per instructions. They were instructed to call you for further information.

Samples--Water--Mine Run

Samples were taken on August 18, 1980, from the following discharge points;

Sample #1----------Swan Portal

Sample #2----------Santa Cruz-Decline Collar

Sample #3----------Total Discharge-St. Louis Portal

Sample #4----------Blaine Tunnel-at the collar of the Blaine Shaft

2/3 Sample #5----------St. Louis Tunnel Discharge from the SE Drift

3/12 Sample #6----------St. Louis Tunnel Discharge from the North Drift

1/12 Sample #7----------St. Louis Tunnel Discharge from the 145 Raise Area

RICO ARGENTINE MINING CO.
AREA CODE 303-967-2281
P.O. BOX 158
RICO, COLORADO 81332



If you have any questions, I will be available at any time to answer.

Very truly yours,

O. L. Jahnke

O. L. JAHNKE
General Manager

OLJ/mj

J. Whyte

# COMMERCIAL TESTING & ENGINEERING CO.

GENERAL OFFICES: 228 NORTH LA SALLE STREET, CHICAGO, ILLINOIS 60601 · AREA CODE 312 726-8434

SINCE 1908

Reply to
Instrumental Analysis Division
490 Orchard Street
Golden, CO 80401

Phone: 303-278-9521

Sept. 29, 1980

Mr. R. L. Dent
Anaconda Copper Co.
555 Sevententh St.
Denver, CO 80217

OCT 3 1980

Re: IAD #97-E986-452-09

ANALYTICAL REPORT

Nine samples were received for analyses on August 25, 1980. These samples were given our identification IAD #97-E986-452-09.

The samples were analyzed for total Zinc, Iron, Cadmium, and Lead by flame atomic absorption spectrophotometry following a rigorous digestion in nitric and hydrochloric acids. Mercury was analyzed directly by cold vapor flameless atomic absorption.

The samples were also analyzed for pH and Fluoride by specific ion electrode and sulfate by turbidimetric methods following the procedures of EPA Methods for Chemical Analysis of Water and Wastes, 1979.

The results of these determinations are presented in the following tables and are reported in milligrams per litre (mg/l) except pH.

Table No. I
concentration in mg/l

| Parameter | #1 | #2 | #3 | #4 | #5 |
|---|---|---|---|---|---|
| pH | *1.9 | *3.1 | *1.8 | *1.8 | *1.7 |
| Fluoride | 0.06 | 0.30 | 4.3 | 1.7 | 2.7 |
| Sulfate | 253 | 393 | 562 | 769 | 544 |
| Zinc, total | 1.96 | 1.58 | 5.2 | 1.78 | 2.62 |
| Iron, total | 5.4 | 0.3 | 16.2 | 13.2 | 3.7 |
| Cadmium, total | ≤0.001 | 0.005 | 0.022 | 0.007 | 0.009 |
| Lead, total | ≤0.05 | ≤0.05 | ≤0.05 | ≤0.05 | ≤0.05 |
| Mercury | 0.00005 | 0.00005 | 0.00005 | 0.00005 | 0.00005 |

Table No. II
concentration in mg/l

(- St. Louis outfall discharge) / St. Louis Pond discharge - St Louis outfall discharge

| Parameter | #6 | #7 | #8 | #9 |
|---|---|---|---|---|
| pH | *2.0 | *1.8 | 7.6 | 7.0 |
| Fluoride | 18 | 1.7 | 5.6 | 5.8 |
| Sulfate | 1070 | 505 | 670 | 620 |
| Zinc, total | 27 | 0.50 | 1.28 | 5.00 |
| Iron, total | 102 | 5.6 | 0.13 | 12.8 |
| Cadmium, total | 0.107 | ≤0.001 | ≤0.007 | 0.029 |
| Lead, total | 0.13 | ≤0.05 | ≤0.05 | ≤0.05 |
| Mercury | 0.00005 | 0.00007 | 0.00005 | 0.00005 |
| Cyanide | ---- | ---- | ≤0.01 | ---- |

*pH value may be low due to the possibility that the sample may have been preserved w/acid.

If there are any questions concerning these results, please call.

Bruce A. Hale
Bruce A. Hale
Section Supervisor

M L Jacobs
M. L. Jacobs, Ph.D., Mngr.
Instrumental Analysis Div.

BAH/jw





F 466

Rico

**ANACONDA Minerals Compa...** **Internal Corresponde...**

**Date:** May 21, 1982

**Subject:** Water Quantity and Quality, St. Louis Tunnel: Rico

**From/Location:** Jack Whyte

**To/Location:** John Wilson

I have attached a letter from O. Jahnke dated August 25, 1980 that provides the results of water quality analyses on samples from our underground flows. Specific to our recent conversation, I have summarized results of interest below:

| Parameter | Total Discharge St.Louis Portal | SE Drift St. Louis | North Drift St. Louis | 145 Rise St. Louis |
|---|---|---|---|---|
| Estimated portion of flow | Total | 2/3 | 3/12 | 1/12 |
| Zinc (total) (Mg/1) | 5.2 | 2.62 | 27 | 0.50 |

J. Whyte
Environmental Services Manager

JW/cc

ANACONDA Copper Company

Internal Correspondence

Date: August 27, 1985

Subject: Water Analyses from Contributory Sources

From/Location: D. Cameron -- Rico

To/Location: G. Secor -- DAT

Shutting off part of the water flow to the St. Louis Tunnel is part of the long-term but low-cost options for the Rico problem. Enclosed are results of some water samples taken at various points in the drainage:

| | Zn | Cd ppm | |
|---|---|---|---|
| SL-1 | 27 | 0.010 | Nw crosscut, St. Louis Tunnel |
| SL-2 | 3.5 | 0.016 | SE crosscut, " " " |
| SL-3 | n.d. | n.d. | " " ", drill hole in back 15 gpm |
| SL-4 | 1.0 | 0.003 | " " ", Iron Rod raise, SW side |
| B-1 | 27 | 0.11 | Blaine Level seep to portal |
| B-2 | 0.96 | 0.006 | " " ", diversion to lower workings. |

The highest flow of dirty water is out of the NW crosscut, and we can do nothing about it that I can recommend. We will try to plug the drill hole. Note that the Blaine water and the Southeast crosscut water are not clean as far as Zn and Cd. I believe we can eliminate much of this flow.

I have collected samples from other St. Louis Tunnel holes which I intend to plug pending receipt of hardware. These could serve as pure water supplies(e.g., SL-3) in any plant modification. I will also sample the mine water again as soon as assessment work stops. Enclosed are the new drill hole sample numbers submitted to Rocky Mountain:

| | |
|---|---|
| SL-5 | SE crosscut, warm water ddh. 15 gpm |
| BB-1H | " " ", BB-1 drill station, angle hole |
| BB-1 | " " ", vertical hole |
| BB-2H | " " ", BB-2 drill station, angle hole |
| BB-2 | " " ", verticla hole |

# ATTACHMENT 3

Blaine Tunnel 2012-2013 Documentation

# ATTACHMENT 3-1

Blaine Tunnel Flume Design

VIRTUAL POLYMER
COMPOUNDS, LLC

10478 Ridge Road • Medina, New York 14103
Phone: 585-735-9668 • Toll Free: 888-290-9522
Fax: 585-735-9965 • www.virtualpolymercompounds.com

Administrative Office: One John James Audubon Pkwy • Amherst, NY 14228

# Extra Large Trapezoidal Flume

| Head Feet | CFS | GPM |
|---|---|---|
| 0.03 | 0.000 | 0.07 |
| 0.05 | 0.001 | 0.26 |
| 0.10 | 0.004 | 1.16 |
| 0.15 | 0.010 | 4.67 |
| 0.20 | 0.022 | 9.98 |
| 0.25 | 0.040 | 17.97 |
| 0.30 | 0.065 | 29.06 |
| 0.35 | 0.097 | 43.63 |
| 0.40 | 0.138 | 62.05 |
| 0.45 | 0.189 | 84.64 |

| Head Feet | CFS | GPM |
|---|---|---|
| 0.50 | 0.249 | 111.74 |
| 0.55 | 0.320 | 143.66 |
| 0.60 | 0.403 | 180.70 |
| 0.65 | 0.497 | 223.16 |
| 0.70 | 0.605 | 271.30 |
| 0.75 | 0.725 | 325.42 |
| 0.80 | 0.860 | 385.78 |
| 0.85 | 1.009 | 452.64 |
| 0.90 | 1.173 | 526.25 |
| 0.95 | 1.352 | 606.87 |

VIRTUAL POLYMER
COMPOUNDS, LLC
10478 Ridge Road • Medina, New York 14103
Phone: 585-735-9668 • Toll Free: 888-290-9522
Fax: 585-735-9965 • www.virtualpolymercompounds.com
Administrative Office: One John James Audubon Pkwy • Amherst, NY 14228

# Extra Large Trapezoidal Flume

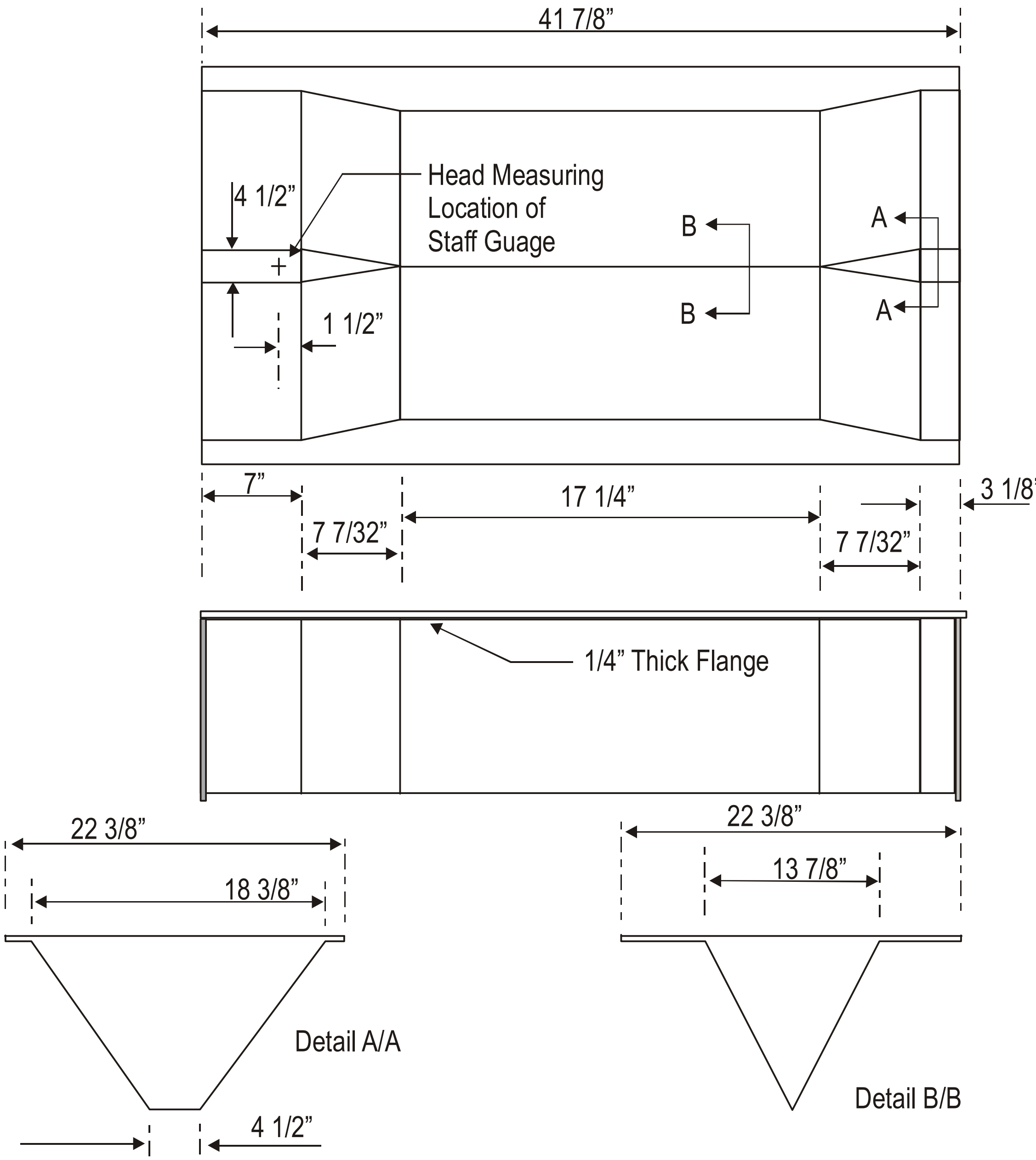



**Plate 24**

## ATTACHMENT 3-2

Hach Sigma 950 Ultrasonic Depth Sensor Specifications

# Sigma 950 Series Permanent/Portable Open Channel Flow Meters




*Sigma 950 Series Permanent/Portable Open Channel Flow Meters provide portable and/or permanent single-channel monitoring plus water quality testing, process control interface, and digital display. Both models offer maximum flexibility for multiple applications—including surcharge or reversed flow conditions, weirs and flumes, and small-to-large channels. Up to three different level sensor technologies and velocity in one meter.*

## Features and Benefits

### Versatility and Customization

The Sigma 950 series are the meters of choice by flow professionals, consultants, and municipalities. Choose from any of the following technologies to fit your application.

- *Use the Submerged Area/Velocity flow meter to measure flow in collections systems for periods up to 40 days using our 6 amp-hr gel electrolyte battery.*
- *Use any of our level technologies when primary devices (Weirs and Flumes) are available to measure level and calculate flow.*
- *The bubbler level technology is ideal for applications with high winds, high temperature or when foam is present.*
- *The combination of bubbler level technology and doppler velocity is the favorite of storm water professionals.*
- *The ultrasonic level technology is ideal to monitor industrial discharges for your Pre-treatment program in combination of any of our Automatic Wastewater samplers.*

### Sampler Pacing and Equipment Control

Control samplers, pumps, or other equipment for monitored flow based on selected parameter(s) of high/low set points and built-in relay outputs. Sampler pacing provides the ability to document overflow problems.

### Easy to Use Interface

The large LCD graphics quickly displays information on-site (available in 10 languages) without the inconvenience of paper charts. The built-in keypad makes using laptops in the field optional. A single keystroke can provide an instantaneous data summary and review of all program settings.

### Communications and Data Storage Options

Industry standard SCADA MODBUS ASCII protocol is included in all Sigma 950 flow meters. 4-20 mA outputs are available for flexible integration with a SCADA system. Remote communications is available via modem or RS-232 connection. Store 18,000 data points in memory (expandable to 116,000 data points).

### Superior Submersible Area Velocity Sensor for Open Channel Applications

The Sigma 950 AV Optiflo flow meter provides Doppler velocity monitoring that uses advanced ultrasonic, one-MHz Doppler technology for flow measurements. This technology avoids signal dropouts and ensures high levels of accuracy in low-flow, full-pipe, or reversed-flow conditions. Installation is fast and single point atmospheric calibration is easy.

### Applications

Sigma 950 Permanent/Portable Open Channel Flow Meter

- *Long term or permanent flow studies*
- *Sanitary sewer evaluation studies*
- *CSO studies and monitoring*
- *NPDES stormwater compliance*
- *Industrial compliance monitoring*

Sigma 950 AV Optiflo Permanent/Portable Open Channel Flow Meter

- *Applications involving frequent moving of meter to different site conditions*

WW

IW

C

# Specifications*

## Flow Meter Specifications

### *Units of Measurement*
*Flow:* gps, gpm, gph, lps, lpm, lph, mgd, afd, cfs, cfm, cfh, cfd, $m^3s$, $m^3m$, $m^3h$, $m^3d$
*Totalized Flow:* L, $m^3$, $ft.^3$, gal., acre-ft.

### *Primary Devices*
*Flumes:* Parshall, Palmer Bowlus, Leopold-Lagco, H, HL, HS, trapezoidal
*Weirs:* V-notch (22.5 to 120°)
Contracted/non-contracted rectangular, Thelmar, Compound Cipolletti
*Manning Equation:* Round, U rectangular, and trapezoidal channels
*Flow Nozzles:* California Pipe
*Head vs. Flow:* Custom programmable curve (up to 99 points)

### *Operating Temperature*
-10 to 65.5°C (14 to 150°F)

### *Storage Temperature*
-40 to 80°C (-40 to 176°F)

### *Humidity*
0 to 100%, condensing

### *Time-Based Accuracy*
±6 seconds (± 0.007%) per day

### *Air Intake*
Atmospheric pressure reference is desiccant protected

### *Totalizers*
8-digit resettable and 8-digit non-resettable LCD software totalizer
Optional 6-digit non-resettable mechanical totalizer

### *Graphics Display*
Back lit LCD
Auto-off when not in use
(under battery operation)
*SCII Mode:* 8 line x 40 character
*Graphics Mode:* 60 x 240 dot
*Dimensions:* 3.8 x 12.7 cm (1.5 x 5 in.)
*Displays:* level vs. time, flow vs. time
*Optional Displays:* rainfall, pH, ORP, temperature, DO, conductivity vs. time, sampler events, and alarm events

### *Keypad*
21 position sealed membrane switch with blinking green LED to indicate power on
Four “soft keys”, functions defined by display

### *Data Logging*
*“Smart” Dynamic memory allocation automatically partitions memory to provide the maximum logging time. No manual memory partitioning required.*

*Memory Mode:* Either slate or wrap-around may be selected
*Data Points:* Approximately 20,000 standard. Expandable up to 116,000 data points.
*Daily Statistics:* Available for up to 32 days
*Recording Intervals:* 1, 2, 3, 5, 6, 10, 12, 15, 20, 30, or 60-minute intervals

### *Program Memory*
Non-volatile programmable flash, can be updated via RS-232 port

### *Sampler Output*
12 to 17 Vdc pulse, 100 mA maximum at 500 ms duration

### *Communications*
*RS-232:* Up to 19,200 baud
SCADA MODBUS communication protocol via RS-232 or optional modem
*Modem (optional):*14,400 bps; V.32 bia, V.42, MNP2-4 error correction. V.42 bis MNP5 data compression. MNP 10-EC Cellular Protocol Pager

### *Enclosure Material*
ABS, UV resistant

### *Enclosure Rating*
NEMA 4X,6

### *Power Options*
12 Vdc supplied from 6 amp-hr. gel electrolyte rechargeable battery
4 amp-hr. Ni-Cad rechargeable battery
Lantern battery pack with two 6-Volt lantern batteries
115 Vac, 230 Vac, or 100 Vac power converter with battery charger

### *Dimensions*
34.3 H x 25.4 W x 24.1 D cm
(13.5 x 10.0 x 9.5 in.)

### *Weight*
5 kg (11 lbs.) not including power source

## Sensor Specifications

<u>950 BUBBLER SENSOR</u>

### *Range*
0.003 to 3.6 m (0.01 to 11.75 ft.)

### *Accuracy*
±0.003 m (±0.011 ft.)
(linearity and hysteresis at 22°C (72°F)) from 0.01 to 11.75 feet

### *Ambient Operating Temperature*
-18 to 63°C (0 to 145°F)

### *Compensated Temperature*
0 to 59°C (32 to 138°F)

### *Temperature Error*
±0.0003 ft./°F (maximum error within compensated temperature range per degree of change)

### *Air Intakes*
Bubble source and reference port desiccant protected.
Fittings provided for remote intakes.

### *Filter*
10 micron on bubble source intake

### *Line Purge*
Bubble line is high pressure purged at programmed intervals, or in manual mode on demand

### *Line Size*
0.32 cm (1/8 in.) ID standard

### *Line Lengths*
160 m (500 ft.) maximum

<u>950 DOWNLOOKING ULTRASONIC DEPTH SENSOR</u>

*<u>50 kHz Ultrasonic Sensor</u>*

### *Range*
38.1 cm to 9.1 m (15 in. to 30 ft.) sensor to liquid

### *Accuracy*
1 to 10 ft. ±0.01 ft. (±0.003 m)
(at 22°C (72°F), still air, 40 to 70% relative humidity)

### *Span*
0 to 8.84 m, (0 to 29 ft.)

### *Ambient Operating Temperature*
-18 to 60°C (0 to 140°F)

### *Temperature Error*
±0.000047 ft./F° (maximum error within compensated temperature range per degree of change)

### *Resolution*
0.0011 ft.

### *Material*
PVC housing
Buna-N acoustic window

### *Cable*
4-conductor with integral stainless steel support cable
*Standard Length:* 7.6 m (25 ft.)

*Continued on next page.*

## Specifications continued

### Crystal Specification
11.5° included beam angle

### Dimensions
9.5 H x 7 D cm (3.75 x 2.75 in.)

### Weight
0.7 kg (1.5 lbs.)

*75 kHz Ultrasonic Sensor*

### Range
23 cm to 3.3 m (9 in. to 10.8 ft.)
sensor to liquid

### Accuracy
1 to 10 ft. ±0.01 ft. (±0.003 m)
(at 22°C (72°F), still air, 40 to 70%
relative humidity)

### Span
0 to 4.57 m (0 to 15 ft.)

### Ambient Operating Temperature
-18 to 60°C (0 to 140°F)

### Temperature Error
±0.000047 ft./°F (maximum error within compensated temperature range per degree of change)

### Resolution
0.0011 ft.

### Material
PVC housing
Buna-N acoustic window

### Cable
4-conductor with integral stainless steel support cable
*Length:* 7.6 m (25 ft.) standard

### Crystal Specification
5° beam angle with horn

### Dimensions
12.7 H x 5.7 D cm (5.0 x 2.25 in.)

### Weight
0.7 kg (1.5 lbs.)

75 KHZ IN-PIPE ZERO DEADBAND ULTRASONIC DEPTH SENSOR

### Range
From sensor to liquid,
0 to 2.4 m (0 to 8 ft.)

### Accuracy
0.038 to 2.4 m ±0.003 m
(0.125 to 8 ft. ±0.01 ft.)
at 22°C (72°F), still air, 40 to 70%
relative humidity

### Span
0.038 to 4.57 m (0.125 to 15 ft.)

### Ambient Operating Temperature
-18 to 60°C (0 to 140°F)

### Temperature Error
±0.00005 m/°C (±0.0001 ft./°F)
maximum error within compensated temperature range per degree of change

### Resolution
0.019 cm (0.0075 in.)

### Material
Stat-Kon® A-E ABS Plastic

### Cable
4-conductor
*Standard Length:* 7.6 m (25 ft.)
*Custom Length:* Up to 305 m (1000 ft.) using RS485 two wire remote sensor option

### Crystal Specification
7° beam angle

### Dimensions
4.44 D x 31.5 L cm (1.75 x 12.4 in.)

### Connection
Bare lead connection via 3658 junction box or quick connect

950 SUBMERGED DEPTH ONLY SENSOR

### Range
*2.5 psi:* 0.01 to 1.75 m (0.04 to 5.75 ft.)

### Accuracy
±0.1% full scale (non-linearity and hysteresis)

### Transducer
*Type:* Differential piezo resistive with balanced bridge
*Orientation:* Inverted

### Maximum Allowable Level
6x over pressure

### Ambient Operating Temperature
0 to 71°C (32 to 160°F)

### Compensated Temperature
0 to 36°C (32 to 96°F)

### Temperature Error:
*2.5 psi:* 0.04 to 5.75 ft. ±0.006 ft./F°
(Max error within compensated temp range per degree of change)

### Air Intake
Atmospheric pressure reference is desiccant protected

### Material
316 stainless steel body with titanium diaphragm

### Cable
4-conductor polyurethane sensor cable with air vent
*Length:* 7.6 m (25 ft.) standard;
76 m (250 ft.) maximum

### Dimensions
*Transducer Only*: 2.54 x 17.2 cm
(1 x 6.75 in.)
*Probe Frontal Area:* 0.875 $in^2$

### Weight
0.7 kg (1.5 lbs.)

SUBMERGED AREA/VELOCITY SENSOR

*Velocity Measurement*

### Method
Doppler ultrasound Twin 1 MHz piezoelectric crystals

### Accuracy[1]
±2% of reading

### Recommended Range
-1.52 to 6.10 m/s (-5 to 20 ft/s)

### Typical Minimum Depth
2 cm (0.8 in.)

### Zero Stability
< 0.015 m/s (< 0.05 ft/s)

*Depth Measurement*

### Method
Pressure transducer with stainless steel diaphragm

### Accuracy[2]
±0.16% full scale ±1.5% of reading at constant temp (± 2.5°C)
±0.20% full scale ±1.75% of reading from 0 to 30°C (32 to 86°F)
±0.25% full scale ±2.1% of reading from 0 to 70°C (32 to 158°F)

### Depth Range
*Standard:* 0 to 3 m (0 to 10 ft.)
*Extended:* 0 to 9 m (0 to 30 ft.)

### Maximum Allowable Depth
*Standard:* 10.5 m (34.5 ft.)
*Extended:* 31.5 m (103.5 ft.)

### Velocity-Induced Depth Error
Compensated based on pipe geometry and flow velocity

### Air Intake
Atmospheric pressure reference is desiccant protected

*[1]When the sensor is out of the water, the system may report velocity readings of up to 0.76 m/s due to Radio Frequency Interferences at frequencies of 140 MHz to 170 MHz and 300 MHz with field strengths greater than 3 V/m.*

*[2]For temperatures above 40°C (104°F) add ±0.3 cm/°C (0.03 in./°F)*

Continued on next page.

## Specifications *continued*

General

**Material**
Noryl® plastic outer shell with epoxy potting within

**Power Consumption**
≤ 1.2 W @ 12 Vdc

**Cable**
*Material:* Urethane cable with air vent
*Standard Length:* 9, 15, 23 and 30.5m (30, 50, 75 and 100 ft.)
*Custom Length:* 30.75 to 76 m (101 to 250 ft.) maximum
*Diameter:* 0.91 cm (0.36 in.)

**Dimensions**
2 H x 3.8 W x 13.5 L cm
(0.8 x 1.5 x 5.31 in.)

**Operating Temperature**
0 to 70°C (32 to 158°F)

**Depth Compensated Temperature**
0 to 70°C (32 to 158°F)

BUBBLER AREA/VELOCITY SENSOR

*Depth Measurement*

**Method**
Doppler principle/pressure transducer

**Range**
0.003 to 3.6 m (0.01 to 11.75 ft.)

**Accuracy**
0.01 to 11.75 ft. ±0.011 ft. (0.033 m) (linearity and hysteresis at 22°C (72°F))

**Ambient Operating Temperature**
-18 to 63°C (0 to 145°F)

**Compensated Temperature**
0 to 59°C (32 to 136°F)

**Temperature Error**
±0.0003 ft./°F (maximum error within compensated temperature range per degree of change)

**Air Intakes**
Bubble source and reference port desiccant protected.
Fittings provided for remote intakes.

**Filters**
10 micron on bubble source intake

**Line Purge**
Bubble line is high pressure purged at programmed intervals, or in manual mode on demand

*Velocity Measurement*

**Method**
Doppler ultrasonic

**Transducer Type**
Twin 1 MHz piezoelectric crystals

**Range**
-1.52 to 6.10 m/s (-5 to 20 fps)

**Zero Stability**
< 0.015 m/s (0.05 fps)

**Accuracy**
±2% of reading

**Depth for Velocity**
2 cm (0.8 in.) minimum, typical

**Operating Temperature**
-18 to 60°C (0 to 140°F)

**Dimensions**
1.12 x 3.81 x 6.86 cm
(0.44 x 1.5 x 2.7 in.)

LOW PROFILE VELOCITY ONLY SENSOR

**Method**
Doppler principle

**Accuracy**
±2% of reading

**Range**
-1.52 to 6.1 ms (-5 to +20 ft/s)

**Zero Stability**
±1.52 cm/s (±0.05 ft/s)

**Resolution**
0.3 cm/s (0.01 ft/s)

**Response Time**
4.8 seconds

**Profile Time**
4.8 seconds

**Nose Angle**
20° from horizontal

**Cable**
*Length:* 7.6 m (25 ft.) standard; custom cable lengths to 76 m (250 ft.)
*Diameter:* 0.57 cm (0.225 in.)

**Materials**
*Sensor:* Polymer
*Cable:* Urethane Jacket
*Mounting Hardware:* Stainless steel

**Dimensions**
6.86L x 3.81W x 1.12H cm
(2.7 x 1.5 x 0.44 in.)

### Factory Installed Options

pH-TEMPERATURE OR ORP METER

**Control/Logging**
Log pH-temperature or ORP independent of flow or in conjunction with flow; also controls sample collection in response to value exceeding low/high set points

**pH/Temperature Sensor**
Temperature compensated; impact resistant ABS plastic body; combination electrode with porous Teflon® junction

**Measurement Range**
2 to 12 pH within specifications;
0 to 14 pH maximum range

**Operating Temperature**
-18 to 80°C (0 to 176°F)

**Recording Intervals**
1, 2, 3, 5, 6, 10, 12, 15, 30, and 60 minutes

**Probe Pre-Amplifier/Junction Box**
NEMA 4X with labeled terminal strip

**Dimensions**
1.9 x 15.2 cm (0.75 x 6 in.) with 1.9-cm (0.75-in.) MPT cable end

INTEGRAL DISSOLVED OXYGEN METER

**Control/Logging**
Field selectable to log dissolved oxygen independent of flow or in conjunction with flow; also controls sample collection in response to value exceeding low/high set points

**Measurement Method**
Polargraphic

**Sensor**
Temperature compensated; impact resistant polypropylene body

*Continued on next page.*

## Specifications *continued*

*Measurement Range*
0 to 20 mg/L dissolved oxygen

*Resolution*
0.01 mg/L

*Accuracy*
±0.2 mg/L

*Operating Temperature*
0 to 50°C (32 to 122°F)

*Dimensions*
1.65 x 12.7 cm (0.65 x 5 in.) with
1.9-cm (0.75-in.) MPT cable end

INTEGRAL
CONDUCTIVITY/TEMPERATURE METER

*Control/Logging*
Field selectable to log conductivity independent of flow or in conjunction with flow, also controls sample collection in response to value exceeding low/high set points

*Sensor*
Temperature compensated;
impact resistant polypropylene body

*Measurement Range*
0 to 100 mS/cm

*Resolution*
0.01 mS/cm or 0.01 µS/cm
(user selectable)

*Accuracy*
±1% of reading +0.05 mS/cm

*Operating Temperature*
0 to 50°C (32 to 122°F)

*Dimensions*
1.70 x 12.7 cm (0.67 x 5 in.)
with1.9-cm (0.75-in.) MPT cable end

RAIN GAUGE INPUT

For use with Hach Tipping Bucket Rain Gauge.
Flow Meter records rainfall data in 0.01 in. increments.

ANALOG INPUT CHANNELS

Up to seven additional data-logging channels record data from external source(s)
Field assignable units
-4.5 to +4.5 Vdc; ±0.5% full scale voltage accuracy
0 to 20 mA; ±0.2% full scale 4-20 mA accuracy with 200 ohm impedance

4 - 20 MA OUTPUTS

Up to two integral user assignable outputs
Optically isolated
Up to 600 ohm load per output
0.1 % FS error
24 Vdc - no load
Insulation voltage between flow meter and 4-20 mA output - 2500 Vac, between the two 4-20 mA outputs - 1500 Vac

ALARM RELAYS

(4) 10 amp/120 Vac or 5 amp/250 Vac form C relays
User assignable for any internal or external data channel or event

MECHANICAL TOTALIZER

6-digit non-resettable mechanical totalizer
*Selectable units:* gal., liters, ft.$^3$, m$^3$, acre-ft.

MODEM

14,400 baud rate
CRC auto to check sum
FCC approved
Cellular compatible

EXPANDED MEMORY

Increase memory from 18,432 data points to 116,736 data points

AC POWER BACKUP

Provides power in the event of an AC power failure
Internal trickle charger maintains 6 amp-hour battery

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**Specifications subject to change without notice.*

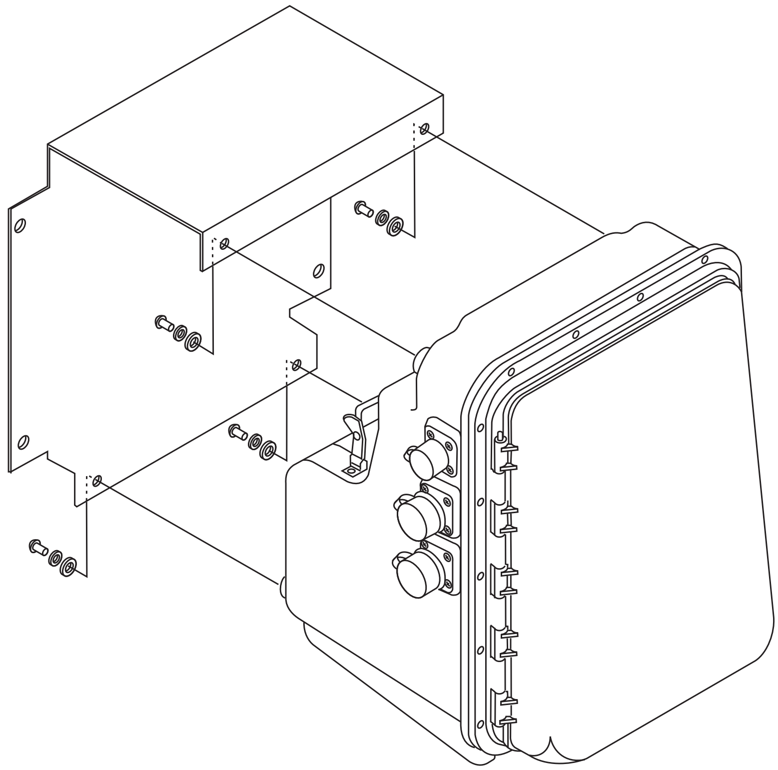
# Engineering Specifications

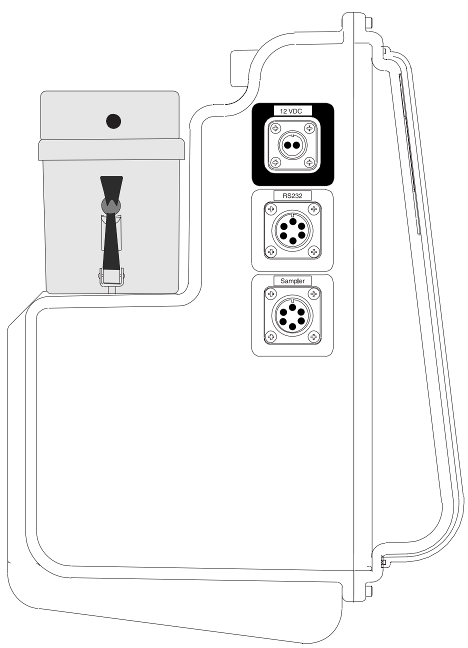
## Flow Meter

1. The flow meter shall operate on 12 Vdc, which is supplied by a battery or 115 Vac power converters.
2. All electrical components shall be enclosed in a NEMA 4X-6 enclosure. The enclosure shall have a continuous hinged front cover to protect the display and keypad and shall maintain NEMA 4X,6 with the cover open.
3. The enclosure shall contain desiccant and a front panel humidity indicator.
4. Current data shall be displayed on the flow meter front panel by means of an external push button on the enclosure. The meter shall not require opening of a cover to see current status.
5. The meter shall have an 8 line x 40-character backlit liquid crystal graphics display. In addition to indicating all programming steps and current status such as level, velocity and flow rate, the display shall show all logged data in field selectable tabular and graphics (x-y plot) formats.
6. All program entries shall be entered via a sealed front panel keypad, and indicated on the front panel display. The keypad and display shall meet NEMA 4X-6 standards.
7. A personal computer or any other external means shall not be required to program the flow meter or integral logger or to access data.
8. Flow meter programming/measurements:
   a. The flow meters shall be field programmable for primary devices including:
      i. Weirs: V-notch weirs (any angle from 22.5 to 120 degrees, compound V-notch/rectangular weirs, contracted and non-contracted rectangular weirs, trapezoidal weirs, and ThelMar weirs.
      ii. Flumes: Parshall (1 to 144 inch), Palmer Bowlus (4 to 72 inch), trapezoidal (60 degree small, large, and extra large, 45 degree 2 and 12 inch), H. HL, and HS type flumes, and Leopold-Lagco (4 to 72 inch).
      iii. Nozzle: California pipe method; Manning equation for round, U-channel, rectangular, and trapezoidal cross sections; power curve equation.
      iv. Head vs. flow tables: Two tables of up to 99 (head, flow) points per table (tables may be stored in flow meter's memory and retrieved as required).
   b. Field selectable units of measurement shall include:
      i. Level: Inches, feet, centimeters, and meters.
      ii. Flow rate: GPS, GPM, GPH, MGD, AFD, LPS, LPM, LPH, CFS, CFM, CFH, CFD, CMS, CMM, CMH, CMD.
      iii. Total flow: Gallons, cubic feet, acre-feet, liters, and cubic meters.
9. Flow totalizing:
   a. The flow meter shall have two software totalizers, one resettable and the other resettable.
   b. (Optional) The meter shall include a 6-digit non-resettable electro-mechanical totalizer, protected to meet NEMA 4X, 6 standards.
10. Sampler pacing:
    a. The flow meter shall have a 12 Vdc pulse output for pacing an automatic liquid sampler in proportion to flow, with field selectable flow volume between pulses.
    b. The meter shall be capable of initiating a sampler on level, flow rate, and flow rate of change.
11. Integral metering devices (optional):
    a. The meter shall be equipped with an integral pH-temperature/ORP meter. The pH meter shall have a range of 0 to 14 pH with a ±1% resolution over an operating range of 0 to 176 degrees F.
    b. The meter shall be equipped with an integral temperature meter. The temperature meter shall have an operating range of 0 to 176 degrees F. The meter shall include a platinum RTD probe in a stainless steel body with 25-foot cable.
    c. The meter shall be equipped with an integral dissolved oxygen (DO) meter. The DO meter shall have a range of 0 to 20 mg/L (DO) with 0.01 mg/L resolution and ±0.02 mg/L accuracy.
    d. The meter shall be equipped with an integral conductivity meter. The conductivity meter shall have a range of 0 to 100 mS/cm with 0.01 mS/cm resolution and 1% (0.05mS/cm) of reading accuracy.
    e. The meter shall be equipped with a rain gauge input. The sampler shall accept contact closure inputs from an external rain gauge.
    f. The meter shall be equipped with seven external analog inputs. The first four channels shall be capable of logging a 4-20 mA current input, and the remaining three channels shall be set up to log -4.5 to +4.5 Vdc voltage input.
12. The flow meter and sensor shall be the Sigma Model 950 Permanent/Portable Open Channel Flow Meter OR Sigma Model 950 AV Optiflo Permanent/Portable Open Channel Flow Meter manufactured by Hach Company.

## Dimensions

Placement of Sigma 950 Series Permanent/Portable Open Channel Flow Meters depends on the suitability of the monitoring site. Select sites that have normalized flow and minimal turbulence. Turbulence can make it difficult to detect an average velocity in the flow stream. Obstructions, vertical drops, pipe bends, and elbows can create turbulence and affect the accuracy of measurements. Mounting options for Sigma 950 flow meters include wall mounting, suspension harness installation, or manhole rung hanger.





# Ordering Information

## Complete Flow Meter Systems

| | |
|---|---|
| **3672950** | 950 Bubbler Flow Meter; includes 25 ft. tubing |
| **3680950** | 950 Submerged Pressure Flow Meter; includes 25 ft. sensor cable |
| **3286951** | 950 75 kHz Down-look Ultrasonic Flow Meter; includes 25 ft. sensor cable |
| **3286952** | 950 75 kHz In-Pipe Ultrasonic Flow Meter; includes 25 ft. sensor cable |
| **3248950** | 950 Bubbler AV Flow Meter; includes 25 ft. of sensor cable |
| **3522950** | 950 Submerged AV Flow Meter; includes 25 ft. of sensor cable |
| **3959952** | 950 75k Hz Ultrasonic AV Flow Meter with In Pipe Ultrasonic and Velocity Sensors |

## Integral Water Quality Options and Sensors

| | |
|---|---|
| **2684** | Factory Installed Integral pH-Temp/ORP Sensor; includes pre-amp interface |
| **3328** | pH-Temperature Sensor (grounded); includes 25 ft. cable |
| **2080** | ORP Sensor; includes 25 ft. cable |
| **3226** | Factory installed DO and Conductivity Sensor; includes pre-amp interface |
| **3228** | Factory installed DO and EC Option with three 4-20mA Input Data Logging, includes pre-amp interface |
| **3216** | DO Probe Kit; includes 25 ft. cable. |
| **3225** | Conductivity Probe Kit; includes 25 ft. cable |
| **3222** | DO Probe only; includes 25 ft. cable |
| **3223** | Conductivity Probe only; includes 25 ft. cable |

## Communication and Control Interfaces

| | |
|---|---|
| **2676** | First 4-20 mA Output; includes 25 ft. cable |
| **2923** | Second 4-20 mA Output |
| **2691** | First Set Two (2) Alarm Relays with settable trip points |
| **2707** | Second Set Two (2) Alarm Relays with settable trip points |
| **4578** | Modem; 14,400 baud (domestic lines only) |

## Sensor Mounting Hardware

| | |
|---|---|
| **1361** | Spring Ring for 6-in. diameter pipe |
| **1362** | Spring Ring for 8-in. diameter pipe |
| **1363** | Spring Ring for 10-in. diameter pipe |
| **1364** | Spring Ring for 12-in. diameter pipe |
| **3263** | Sensor Mounting Clip; for 88000, wafer velocity, and bubbler level velocity sensors |
| **3868** | Portable Bracket; for in-pipe ultrasonic sensor mounting clip |
| **3875** | Permanent In-Pipe Ultrasonic Sensor Mounting Bracket |
| **3305** | Velocity Sensor Mounting Plate |
| **9574** | Insertion Tool; for non-confined space entry |
| **2974** | Permanent Wall Mount Bracket; for down-looking ultrasonic sensor |
| **2904** | Floor or Wall Adjustable Mounting Bracket; for down-looking ultrasonic sensor |
| **9538** | Tripod Mounting Bracket; for down-looking ultrasonic sensor |
| **2883** | Cable Straightener; for down-looking ultrasonic sensor |
| **3183** | Cable Grip; for down-looking ultrasonic sensor |

## Cables and Interfaces

| | |
|---|---|
| **1727** | Sampler or Flow Meter to PC Cable |
| **3358** | RS232 Extension Cable |

## Accessories

| | |
|---|---|
| **77247-00** | Silicon Oil; dual 50-ml pack (refills 100 sensors) |
| **77248-00** | Silicon Oil Refill Kit; includes dispensing tool and oil packs |
| **77256-00** | Oil-Filled Sub-AV Sensor Kit |
| **77300-00** | Retrofit Kit (converts non oil-filled to oil-filled); includes Silicon Oil Refill Kit |

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*In the interest of improving and updating its equipment, Hach Company reserves the right to alter specifications to equipment at any time.*

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## ATTACHMENT 3-3

Blaine Tunnel Photograph Log

**BLAINE TUNNEL PHOTOGRAPHS**
**EVALUATION OF SOURCE WATER CONTROLS**
**Rico-Argentine Mine Site**
**Dolores County, Colorado**

1. Sandbag dam, flume, and Hach Sigma 950 downlooking ultrasonic depth sensor, looking in from out-by the "inflow" near the vertical timbers.

2. Sandbag dam with flume and Hach Sigma 950 downlooking ultrasonic depth sensor installed in-by the Humboldt Drift.

3. Downlooking ultrasonic depth sensor installed directly above the Blaine flume.


4. Blaine Tunnel pool looking in from the sandbag dam and flume, with the "flowing raise" appearing as an icicle near the back right.

## ATTACHMENT 4

2012 Geophysical Characterization

# Geophysical Logging Results
# Rico-Argentine Mine Site
# Dolores County, Colorado

Prepared for
AMEC Environment & Infrastructure, Inc.
13 September 2012

Prepared by
Layne Christensen Company – Colog Division
810 Quail Street, Suite E, Lakewood, CO 80215
Phone: (303) 279-0171 Fax: (303) 278-0135

## I. Introduction

In accordance with the subcontract task order No.: RICO-01, Project No.: SA11161301, Agreement No.: SD-0218-2011, Layne Christensen Company – Colog Division provided services to acquire geophysical data in the 517 Shaft at the Rico Mine Site in Rico, Colorado. Services were performed during the time period from September 4, 2012 through September 6, 2012.

517 Shaft was approximately 623 feet deep, fully timbered, in a 7'x7' in area. The opening to the shaft was about 220 horizontal feet from the portal in the abandoned 517 mine tunnel. The flooded section of the shaft was measured at a depth of approximately 452 feet and continued to a total depth of 623' as measured by the a small diameter logging probe. Specific surveillance geophysical methods included:

- A downhole video system was used to collect continuous real-time images within the 517 Shaft. As the camera was lowered downward, the collected image was toggled between axial and radial views. As the image was observed, the camera was stopped and controlled by a surface panel to capture 360° pan and tilt images as directed by an AMEC technical advisor. Depth encoding was continuously provided on the real time video image to 0.1 foot accuracy.

- A water quality monitoring device (In-Situ model 9500) was attached to the wireline above the video camera. This device logged a vertical water quality profile and included: pH, temperature, conductivity, dissolve oxygen, and oxidation-reduction potential.

- Vertical flow velocities in the flooded section were observed and recorded with a heat pulse flowmeter device. This probe was lowered to specific locations and apparent velocities were collected.

- Discrete water samples were collected from a few selected depths. Because of the limits of the wireline sampler, time constraints, and downhole water pressures, the sampling device proved to be somewhat inadequate as described in further detail in the sampling section.

Colog provided two trained, experienced technicians, equipment, materials, and supplies necessary to complete the required surveillance, including power supply, wireline, cabling, winches, monitors, tools, spare parts, etc.

In-mine support was provided by personnel from the Colorado Division of Reclamation and Mine Safety (CDRMS). CDRMS provided communication equipment. All on-site activities were carried out in level D PPE with safety constraints following MSHA, OSHA and site specific TSHASPs.

## II. Methodology

### A. Temperature and Fluid Conductivity

Geothermal gradients in the near surface earth are usually dominated by conduction, and are generally linearly increasing with depth due to the relative constancy of the thermal conductivity of earth materials. Convective heat flow within the mine shaft fluid is caused by f fluid entering or leaving the mine shaft at a shaft opening or some permeable interval. Therefore, deviations from the linear thermal gradient can be attributed to fluid movement. Both the thermal gradient and fluid conductivity profile of the mine shaft fluid can be obtained with the same probe. The temperature is measured with a thermistor and the fluid conductivity is measured with a closely spaced Wenner electrical array.

Slope changes in both the temperature and fluid conductivity logs may be indicative of fluid flow between the surrounding fluids (from the formation or shaft intersections) and the mine shaft. Both responses are affected by drilling method, time since circulation, mud type or additives and well development procedures.

The fluid conductivity in the mine shaft is controlled primarily by the salinity. Therefore, salinity stratification, or the introduction of a fluid of different water quality into the mine shaft, can be observed by changes in the fluid conductivity log. Often, fluid exchange influences both the temperature and the fluid conductivity so that the response is evident in both logs.

Temperature corrected conductivity can be converted to equivalent NaCl salinity in parts per million (Bateman and Konen, 1977). A salinity profile can then be plotted which suggests the general water quality trend of the mine shaft fluid.
Fundamental assumptions and limitations inherent in these procedures are as follows:

- The mine shaft temperature log is usually the first log run in a mine shaft and, unlike virtually all other logs, is run while the probe is moving down the hole. The exception to running this probe first, however, would be if any optical measurement is to be acquired. The idea is that the logging of the temperature/conductivity probe may stir up the fluids, inhibiting the optical device.

- The recorded mine shaft temperature is only that of the fluid surrounding the probe, which may or may not be representative of the temperature in the remainder of the shaft or connecting adits.

- In most wells the geothermal gradient is considerably modified by fluid movement in the mine shaft and adjacent rocks.

### B. Troll 9500 Multiparameter Water Quality Instrument

For this project Colog utilized a sub-2inch multiparameter water quality probe manufactured by In-Situ, Inc. The instrument was populated with sensors to collect Fluid Conductivity, Dissolved

Oxygen Saturation, Oxygen Saturation, pH, Fluid Temperature, and Oxidation Reduction Potential.

The ruggedized sensors utilize a wiper-free design to minimize effects in demanding environments such as high sediment loads and rapid flow rates. The 9500 sensors were factory calibrated prior to shipment and field checked before field deployment.

Stabilization criteria were set for each measured parameter and data were collected at a sample rate every 10 seconds. The Troll 9500 was attached to Colog's video cable above the camera in order to monitor conditions in the undisturbed water column within the 517 Shaft. The 9500 was setup at the surface, calibrations checked and deployed under a non-tethered condition (battery powered).

As the video camera was lowered down the shaft, depth information was obtained through the video systems digital encoding system and time tagged to feet below water surface.
After the completion of the initial video survey, the water quality parameter data were downloaded to a laptop computer, quality checked, and presented on the geophysical summary plot next to flow meter data.

## C. Heat Pulse Flowmeter

The Heat Pulse Flowmeter (HFP-4293), from Mount Sopris Instruments is a high resolution device for measuring vertical fluid movement within the mine shaft. This flowmeter is based upon the proven USGS design and works on the thermal fluid tracer concept. Mine shaft fluid is heated or thermally tagged by as much as 1° F with an electrical heater grid. The flow rate is determined by measuring the time between the grid discharge and the peak of the thermal pulse of water reaching an upper or lower thermistor sensor. MSI utilizes flow concentrating diverters to direct fluid flowing in a borehole through the probe flow tube (Figure H-1). However, due to the size and shape of the mine shaft, only a small fraction of the flow cold be forced through the flow tube.

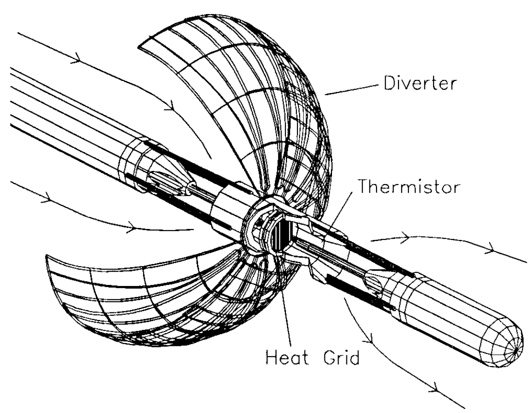


Figure H-1: Heat pulse flowmeter diverter diagram showing fluid flow

The HFP-4293 is calibrated in a flow chamber where flow rate can be controlled and measured. Values for response time are taken for a wide range of flow rates and applied in an empirical curve-fit solution (Figure H-2). The calibration coefficients are entered into the processing software to determine vertical flow rates in gallons/minute. Thermal buoyancy of the heat pulse imposes a small asymmetry on the flow calibration so that the device is slightly less sensitive to upflow than to downflow.

Presently the HFP measures flow from 0.01 to 1.5 gallons/minute (0.038 to 5.69 liters/min) with 0.005 gpm resolution using a 1.125 inch diameter flow tube and standard multilayered flow diverter. The low end flow limit of 0.01 gpm is a function of the current calibration facility in which convective eddy currents as great as 0.01 gpm are generated by differences between water temperature in the calibration device and surrounding air. A more thermally insulated calibration chamber or smaller diameter probe flow tube could allow for significantly lower flow limit with this tool. Higher flow rates can be achieved by increasing thermistor spacing or flow tube and heating grid diameter.

In practice the HFP is run at discrete intervals within a borehole (or in this case, a mine shaft). Intervals are selected based upon review of fluid column logs (temperature, fluid resistivity, etc.), a caliper log and optimally an imaging log (video or acoustic televiewer). Flow was measured at each interval and each test repeated until at least two measurements are recorded within given tolerances. Time to collect flow data is subject to the flow rate and number of intervals tested.

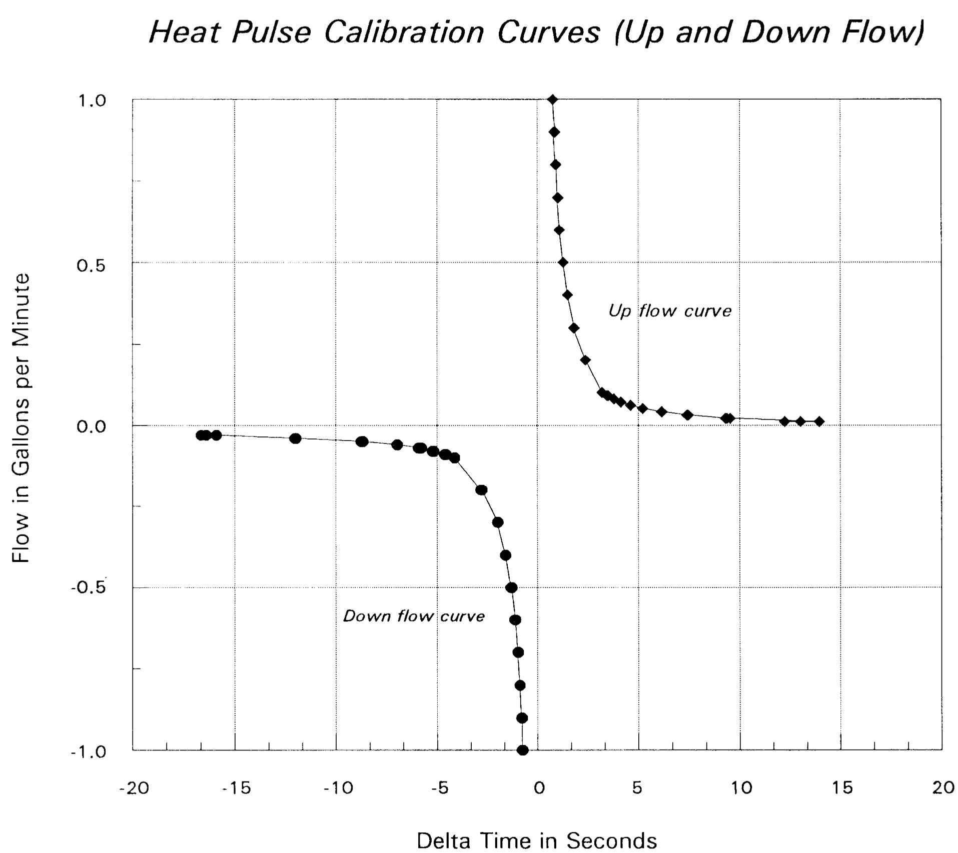


Figure H-2: Heat pulse flowmeter calibration curves used to translate response time to gpm.

A number of factors must be considered when interpreting high-resolution flow data including: 1) the effects of turbulent thermal convection and other secondary flow circulations; 2) real flow regimes are often changing with time as measurements are being made; and, 3) not all permeable intervals may be producing vertical flow under ambient conditions. (Paillet et al, 1994)[1] describes these factors in detail which should be reviewed for a more thorough discussion.

Some of these factors can be minimized by using a flow concentrating diverter. More importantly, flow measurements should be collected in the same intervals under different head conditions. In areas where the flow regime is changing with time, a number of flow measurements should be measured at the same intervals over time and the resulting flow transients interpreted.

### D. Downhole Video Survey

COLOG provided a downhole video survey utilizing a system manufactured by Aries Industries Company. The BT9601 dual view downhole inspection camera contains an articulating side view with 360 degree rotation. The complete stand-alone system utilizes a BT12713 camera control box and is integrated with a ¼" diameter coaxial steel armored 1500 foot cable winch.

Video surveys were recorded on HD/DVD format and viewed in real time as the color camera was lowered downward. As objects were observed the camera functionality allows for still frame focusing, sideward viewing, rotation of side image, light intensity adjustments and overall a complete control of the viewing area.

The video image is limited by artificial light illumination and water clarity. Additional submersible diving lights can be attached to the camera to provide support in large diameters and openings.

## III. Initial Interpretation

The fluid characterization probes were able to provide some information about the state of the water within this shaft. The flow measurements are not quantifiable, as the water was not forced through the small probe inner diameter, but was allowed to flow past the probe within the large shaft cross-section. The flow measurements do, however, demonstrate trends of flow direction and relative magnitude. Changes in flow direction are indicative of inflow or outflow and are generally supported by anomalies in the fluid quality logs.

The heat-pulse flowmeter data indicated no measureable flow at 470 feet. Above this depth, measurements indicated up-flow, and below this depth, down to 495 feet, measurements indicated down flow. This evidence suggests that at about 470 feet water is entering the shaft, and then moving away in both directions. The up-flowing water must be exiting the shaft near the static fluid level, about 452 feet. The down-flowing water appears to be exiting the shaft at about 495 feet, at which depth all vertical flow appears to have stopped. Up-flow is measured again at all stations between 495 feet and 520 feet. This suggests that water is entering the shaft at some point between 520 and 530 feet, and flowing upward, before exiting at about 495 feet. Flow, if any, at 530 feet,

---

[1] Pallet, Crowder and Hess, 1994, High-Resolution Flowmeter Logging - A Unique Combination of Borehole Geophysics and Hydraulics: Part II - Borehole Applications With the Heat-Pulse Flowmeter, Proceedings of the Symposium on the Application of Geophysics to Engineering and Environmental Problems, Boston, Massachusetts, pages 381-404.

and all deeper stations, is not measureable. The increase in the down-flow magnitude between the 475 foot and 480 foot stations suggests inflow between these stations. Likewise, the decreases in the down-flow magnitude between the 480 foot, 485 foot, and 490 foot stations suggests outflow throughout this interval.

The fluid conductivity log registers anomalies at 473 feet and at 497 feet, correlating with the in and out flow suggested by the flow data. The anomaly at 497 feet is corroborated by the dissolved oxygen logs, which show a drop in the oxygen level at this depth. Similarly, there is a slight pH shift at 497 feet. The fluid conductivity is noticeably reduced below 522 feet. This depth corresponds with the obstruction encountered by the video camera. Please note that the In-Situ probe was attached to the video camera, and was also unable to pass the obstruction. Temperature data suggest two distinct environments, one above 539 feet, where the temperature is relatively constant, and one below 539 feet, where the temperature gradually decreases with depth. The broad slope changes below 539 feet are consistent with very slow stratification, as would be expected in a non-flowing environment.

# APPENDIX A

## Geophysical Log Plots

# Geophysical Summary Plot

COLOG — Borehole Geophysics & Hydrophysics — A Division of Layne Christensen Company

| | |
|---|---|
| COMPANY: AMEC | PROJECT: Rico-Argentine Mine |
| DATE LOGGED: 5 Sept. 2012 | WELL: Shaft 517 |


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810 Quail Street, Suite E, Lakewood, CO 80215
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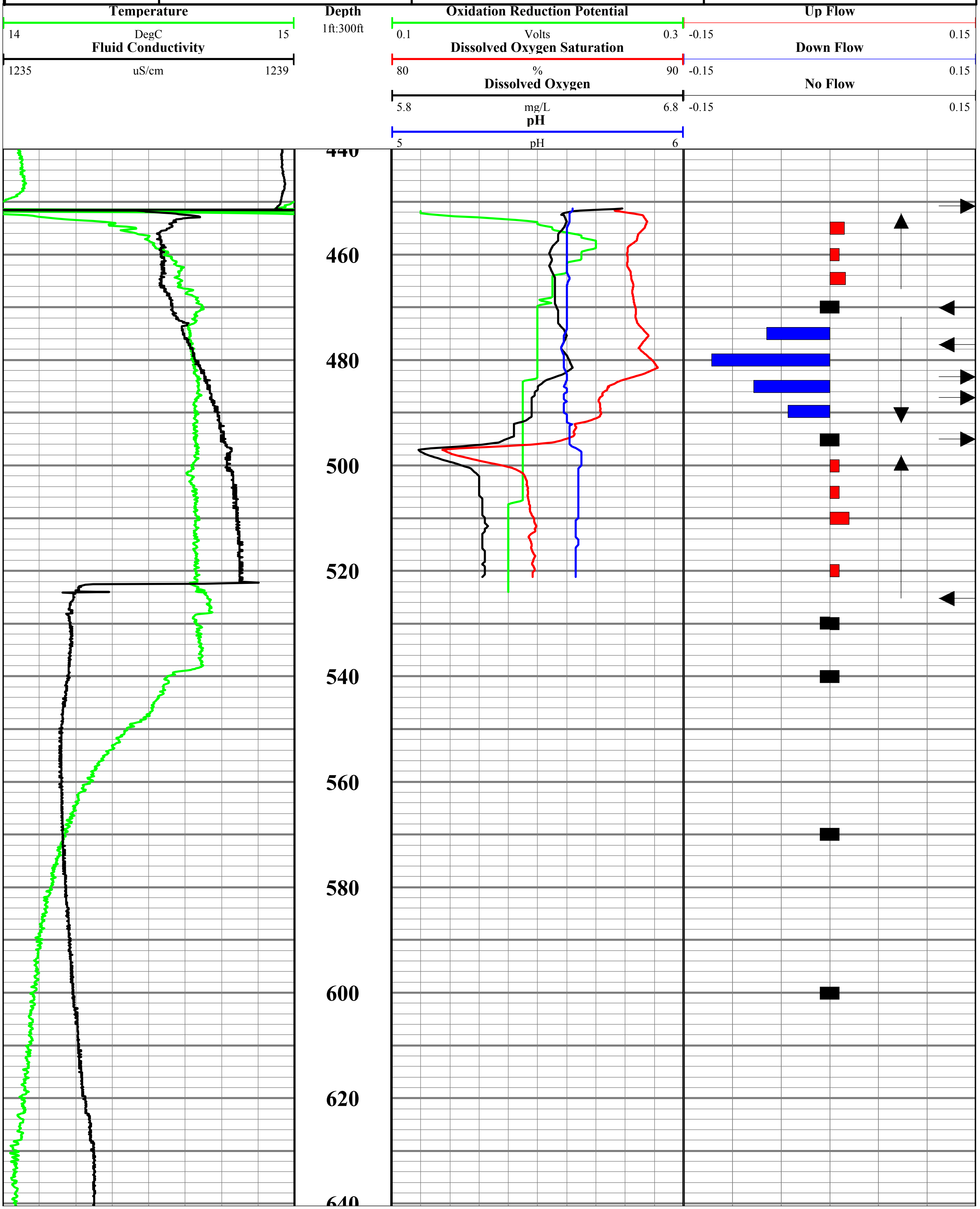
www.colog.com

# APPENDIX B

## Equipment Specifications

In-Situ Inc.

Innovations in
Water Monitoring


# TROLL® 9500 Multiparameter Instrument

The powerful, portable TROLL 9500 Water Quality Instrument is designed for groundwater and surface water monitoring. The unit houses up to nine water quality sensors, internal power, and optional data logger.

## Lower Total Cost of Ownership

- Instrument saves time and money by offering long-lasting internal power, automated low-flow sampling, and telemetry accessibility.
- Field-proven sensors and antifouling system reduce maintenance and site visits.
- Intuitive Win-Situ® 4 Software and Flow-Sense Software improve efficiency by simplifying data collection and management.

## Reliable, Accurate Operation

- Instrument operates in fresh, waste, and marine waters.
- Instrument offers proven performance. Rigorous third-party testing shows that the TROLL 9500 delivers consistent results.
- Sensors are factory calibrated with NIST®-traceable standards (where applicable).

## Outstanding Customer Service

- Free, 24/7 technical support
- Seven-day service for maintenance and calibration (U.S.A. only)

## Logging Models

- ***LTS:*** LTS stands for “Level, Temperature, and one additional Sensor,” such as conductivity, dissolved oxygen (DO), or pH.
- ***Professional:*** This unit offers the highest value for most applications. Instrument allows for several sensors, including conductivity/salinity, DO, ORP, pH, temperature, or depth.
- ***Professional XP:*** The most capable TROLL 9500 offers features available on the Professional and supports XP or “Extended Parameter” sensors—turbidity, ammonium, chloride, or nitrate.

## Non-Logging Models

- ***Profiler:*** Ideal for sampling or vertical profiling, this unit is similar to the Professional, but does not include memory or logging capabilities. Data can be logged to a RuggedReader® Handheld PC or laptop.
- ***Profiler XP:*** This unit offers the same features as the Profiler with the option to use XP sensors.

## Applications

- Coastal deployments—estuaries and wetlands
- Environmental monitoring and spot checking
- Low-flow groundwater sampling
- Remediation and mine water monitoring
- Stormwater management
- Vertical profiling

# ***TROLL***® *9500 Water Quality Sensors*

## *Customizable for Your Application*

Choose from several field-ready sensors. The selected sensor set will determine the diameter of the TROLL 9500—sub-2 inch or sub-4 inch.

- ***Barometric pressure:*** Use this sensor to compensate water level and DO values.
- ***Conductivity:*** Characterize water quality in actual conductivity, specific conductivity, salinity, TDS, or specific gravity.
- ***DO:*** Choose from the optical Rugged Dissolved Oxygen (RDO®) Sensor or Clark cell.
- ***Level/Pressure:*** Non-vented and vented sensors are available for several ranges.
- ***Nutrients:*** Choose from ion-selective electrodes for ammonium, chloride, or nitrate.
- ***pH or pH/ORP:*** Extend field use with durable sensors. The re-buildable pH sensor outlasts traditional sensors.
- ***Temperature:*** Compensate conductivity, DO, pH, and nutrient data with this fast, accurate sensor.
- ***Turbidity or Turbidity/Level:*** Comply with ISO standards. The turbidity sensor uses ISO 7027 method. Optional wiper is available for high-fouling sites or for lengthy deployments.

## *Optical RDO Sensor*

EPA Approved

Breakthrough RDO technology surpasses Clark cell performance by eliminating hydration effects, membranes, electrolyte solution, and stirring.

- ***Rugged performance:*** Wiper-free design excels in demanding environments. Abrasion-resistant foil withstands fouling, high sediment loads, and rapid flow rates. No photobleaching effects.
- ***Automatic setup:*** RDO Cap with pre-loaded calibration coefficients simplifies setup and eliminates programming errors.
- ***Accurate results:*** Operates with low drift over long-term deployments. Excels in hypoxic conditions. Responds quickly and maintains stable response.
- ***Long-lasting calibration:*** Deploys for several months if sensor fouling is minimal and if the foil is not damaged or removed.
- ***Minimal interferences:*** Sensor is unaffected by sulfides, sulfates, hydrogen sulfide, carbon dioxide, ammonia, pH, or chloride.
- ***Fast response:*** Ideal for vertical profiling and dynamically changing conditions.


# ***TROLL*** *9500 Accessories*


## *TROLL® Shield Antifouling System*

The TROLL Shield Guard slows biofouling on TROLL 9500 sensors. The guard extends instrument deployments in coastal environments and at high-fouling sites by up to six weeks.

## *DO Field Bubbler Kit*

For accurate results, use the DO Bubbler Kit for air-saturated water calibrations. The kit reduces time spent on calibration setup.

## *Calibration Solutions*

From easy-to-use Quick Cal Solution to NIST®-traceable standards, In-Situ supplies calibration solutions required to get accurate results. Call for details or visit ***www.in-situ.com***.

## *RuggedCable® Systems, Reels, & Well Accessories*

RuggedCable Systems endure harsh environments and last for years. Titanium twist-lock connectors and Kellems® grip are included. Vented or non-vented cable is available in either Tefzel® or polyurethane. Order customized lengths up to 1,219 m (4,000 ft). Steel or plastic reels make deployment of long cables manageable. Ask us about well-docking accessories.

# ***Real-Time*** *Monitoring for Remediation*


## *Conduct ISCO, ISCR, Biosparging, Air Sparging & More*

The TROLL® 9500 Instrument supports real-time measurement of performance indicators, which allows for a dynamic work strategy per the EPA Triad Approach to site remediation. You can adapt to changing conditions as new data becomes available. This allows you to complete projects more quickly and at a lower cost than when using traditional approaches. The TROLL 9500:

- Features sub-2 inch configuration for key parameters: DO with the RDO® Sensor, conductivity, pH/ORP, temperature, and barometric pressure
- Deploys in harsh conditions. The corrosion-resistant housing is suitable for many remediation applications.
- Reduces grab sampling and labor costs while improving safety when working with treatment chemicals
- Improves performance and reduces maintenance when deployed with the RDO Sensor
- Connects to the TROLL® Link Telemetry System for remote access and external power


# ***TROLL*** *9500 Low-Flow Sampling System*

You can use the TROLL 9500 System with Flow-Sense Software to conduct low-flow purging and sampling. You will collect representative samples, minimize contaminant volatilization, and reduce hazardous waste disposal. To improve efficiency in the field, the system:

- Automates collection of well and pumping information
- Monitors and records stabilization of key water quality parameters
- Automatically generates defensible calibration and sample reports that conform to federal and regional regulations
- Eliminates transcription time and errors


## *Automated Test Setup*

Flow-Sense Software retains all project information—well data, pump performance specifics, tubing details, pumping rate, stabilized drawdown, and parameter stabilization criteria. You can quickly access site information at subsequent sampling events without reentering data.

Win-Situ® Sync Software automatically copies well records and data between a computer and a RuggedReader® Handheld PC.

## *Automated Data Collection*

Stabilization criteria are set for each monitored parameter. Data collection intervals are defined by time or pumped volumes. During sampling, software calculates and displays variance and targets for each parameter. Data is logged at pre-determined intervals and stabilization is achieved when readings meet variation criteria. In addition, you can view data numerically or graphically.

## *Automated Test Report Generation*

After stabilization, stored data can be exported into Excel®. Flow-Sense Software automatically generates full calibration and sample reports that conform to federal and regional regulations. To save time, simply reuse templates at subsequent sampling events.

# *TROLL*® 9500 Multiparameter Instrument

| General | *TROLL 9500 Water Quality Instrument* | | | | |
|---|---|---|---|---|---|
| **Operating temp.** | -5 to 50° C (23 to 122° F) | | | | |
| **Storage temp.** | -40 to 65° C (-40 to 140° F) | | | | |
| **Dimensions & weight** | 4.7 cm (1.85 in) OD x 55.25 cm (21.75 in). With twist-lock hanger: 56.52 cm (22.25 in). Restrictor: 8.9 cm (3.5 in) OD x 21 cm (8.25 in) long; 1.9 kg (4.2 lbs) | | | | |
| **Wetted materials** | PVC, 316L stainless steel, titanium, Acetal, Viton®, nylon. Cable: Tefzel® or polyurethane | | | | |
| **Water tightness rating** | IP68 with all sensors and cable attached. Battery compartment: IP67 without the battery cover or cable attached | | | | |
| **Output options** | RS485/RS232; SDI-12 (optional with SDI-12 adapter); ASCII streaming mode or binary command | | | | |
| **Power** | External: 9-16 VDC (optional). Internal: 2 user-replaceable D batteries (use either alkaline or matched pair of lithium). Use only Saft LSH-20 3.6V lithium D cells. Use of any other battery will void the warranty. | | | | |
| **Logging** | | | | | |
| **Data logging** | 16 programmable tests (defined, scheduled to run, or stored). Logging modes: Linear, Linear Average, Event | | | | |
| **Memory** | 4 MB (222,000 data records[1]) | | | | |
| **Standard Sensors** | ***Accuracy*** | ***Range*** | ***Depth Rating*** | ***Response Time*** | ***Methodology*** |
| **Barometric pressure** | ±0.3% FS | 16.5 psia | Meets highest rating | < 30 sec per 30 m (100 ft) of cable | Silicon strain gauge |
| **Level, Depth, Pressure** | ±0.1% FS or better<br>Sensor accuracy: -5 to 50° C | 15, 30, 100, or 300 psi | *Non-vented*<br>30 psia: 10.90 m (35.76 ft)<br>100 psia: 60.11 m (197.2 ft)<br>300 psia: 200.7 m (658.6 ft)<br>*Vented*<br>15 psig: 10.55 m (34.61 ft)<br>30 psig: 21.10 m (69.21 ft)<br>100 psig: 70.32 m (230.7 ft)<br>300 psig: 211.0 m (692.1 ft) | Instantaneous in thermal equilibrium | Silicon strain gauge<br>(non-vented or vented) |
| **Conductivity** | Low: ±0.5% or 2 µS/cm<br>High: ±0.5% + 2 µS/cm | Low: 5 to 20,000 µS/cm<br>High[2]: 150 to 112,000 µS/cm | Low: Meets highest rating<br>High: Meets highest rating | Low: Instantaneous<br>High: Instantaneous | Std. Methods 2510, EPA 120.1<br>Std. Methods 2510, EPA 120.1 |
| **Dissolved oxygen**<br>***RDO® Sensor[3]*** | ±0.1 mg/L<br>±0.2 mg/L<br>±10% of reading | 0 to 8 mg/L<br>8 to 20 mg/L<br>20 to 50 mg/L | 150 psi from 0 to 50° C<br>300 psi @ 25° C | T90: < 45 sec. T95: < 60 sec.<br>T90: < 45 sec. T95: < 60 sec.<br>T90: < 45 sec. T95: < 60 sec. | *EPA-approved In-Situ Methods[4]*<br>1002-8-2009, 1003-8-2009,<br>1004-8-2009 |
| ***Clark cell electrode*** | ±0.2 mg/L | 0 to 20 mg/L; 0 to 200% saturation | 246 m (807 ft) | 1-mil membrane: 1-2 min @ 25° C<br>2-mil membrane: 90 sec to 3 min | Std. Methods 4500-O G, EPA 360.1 |
| **pH (single)[5] or pH/ORP (combo)[5]** | pH: ±0.1 pH unit<br>ORP: ±5.0 mV | pH: 0 to 12 pH units<br>ORP: ±1400 mV | pH: 211 m (692 ft)<br>pH/ORP: 211 m (692 ft) | pH: < 15 sec, pH 7 to pH 4<br>ORP: < 15 sec | pH: Std. Methods 4500-$H^+$, EPA 150.2<br>ORP: Std. Methods 2580 |
| **Temperature** | ±0.1° C | -5 to 50° C (23 to 122° F) | Meets highest rating | < 30 sec | EPA 170.1 |
| **Extended Parameter (XP) Sensors** | | | | | |
| **Ammonium ($NH_4^+$)** | ±10% | 0.14 to 14,000 ppm N | 14 m (46 ft) | T98: < 60 sec, 1.4 to 14 ppm N | Std. Methods 4500-$NH_3$ D, EPA 350.3 |
| **Chloride ($Cl^-$)** | ±15% | 0.35 to 35,500 ppm Cl | 70 m (231 ft) | T98: < 60 sec, 3.54 to 35.45 ppm Cl | Std. Methods 4500-$Cl^-$ D |
| **Nitrate ($NO_3^-$)** | ±10% | 0.14 to 14,000 ppm N | 14 m (46 ft) | T98: < 60 sec, 1.4 to 14 ppm N | Std. Methods 4500-$NO_3$ D |
| **Turbidity** | ±5% or 2 NTU/FNU | 0 to 2,000 NTU/FNU | 105 m (346 ft) | Instantaneous (5 sec for first reading) | ISO 7027 |
| **Warranty** | TROLL 9500 and all sensors (excluding RDO & ISE sensors) come with a 1-year warranty. RDO Sensor: 3-year warranty. ISE sensors: 90-day warranty. RuggedCable® System: 2-year warranty. | | | | |
| **Notes** | [1]A single data record includes time stamp, temperature, RDO, pH, and conductivity logged in Linear or Linear Average mode. [2]Full operating range: 70 to 200,000 µS/cm.<br>[3]Full operating range: 0 to 50 mg/L. [4]EPA-approved; call for details or visit www.in-situ.com. [5] pH sensor and pH/ORP sensor temperature range: 0 to 50° C. | | | | |



In-Situ Inc.®

***Call to purchase or rent—www.in-situ.com***
221 East Lincoln Avenue, Fort Collins, Colorado, U.S.A. 80524
1-800-446-7488 (toll-free in U.S.A. and Canada)
1-970-498-1500 (U.S.A. and international)

# 2FSA-1000 Discrete Sampler

## Specifications

**Name or Model:** 2FSA-1000 1-liter Sampler Tool

**General Description:** The 2FSA-1000 is a 1-liter discrete sampler tool that connects to any MSI logging system. 2-liter models are available also. Any gases captured at depth can be released into customer-supplied plumbing at the surface.

**Length :** 234 cm (80")

**Diameter :** 40mm (1.6"), 1-liter tool

**Pressure Rating:** 600 Bar (10,000 PSI)

**Weight :** 12.3 Kg (27 lbs), 1-liter tool

**Operating Temperature:** up to 80 C

**Sensor:** user-controlled solenoid piston

**Accuracy :** n/a

**Resolution:** n/a

**Field Applications:**
► Heavy duty, high-torque motor with ball screw drive
► Pressurized sample size easily changed by using different length or OD of reservoir housing.
► Bottom sub encloses sample transfer valve.
► Customer can order reservoir capacities of 1 or 2 liters. Larger capacities available.

# 2WQA-1000, 2PFA-1000, 2SFA-1000

**Name or Model**: 2WQA-100, Temperature-Fluid Resistivity

**General Description**: The 2PFA-1000, combination temperature/fluid resistivity probe, provides valuable information for the hydrologist and groundwater scientist concerning borehole fluid character and flow. The 2PFA-1000 is configured as a “Poly” probe, with a quick-connect probe top that allows it to be easily attached to either a Poly gamma probe or fitted with a probe top adapter to run in stand alone mode. Other versions of this probe, designated 2WQA-1000, 2WQB-1000, or 2WQC-1000 are stand-alone probes with respectively, a Mount Sopris single conductor, four-conductor, or GO/I four-conductor top. Finally, the measurements are also available as a factory-mounted sub that is mounted permanently to the bottom of the 2PEA-1000, Poly Electric (2SFA-1000) or 2PCA-1000, Poly Caliper (2SFB-1000) or 2CAA-1000 Caliper (2SFB-1000) probes. The 2PFA-1000 and its various configurations include a seven electrode mirrored Wenner array for measuring borehole fluid resistivity and a temperature sensor based on a fast response semiconductor device whose output voltage changes linearly with temperature. The resistivity array is an internal cylindrical array open at the bottom of the probe. Borehole fluid passes by the array as the probe is lowered in the hole. The array is completely shielded from the outside borehole, so that only fluid resistivity is measured. The temperature sensor is located at the top of the sensor body, in the center of the three exit ports where the borehole fluid returns to the well bore. The “K” factor for the Wenner array is empirically derived, and is approximately 12, when checked for fluid resistivity ranging from 3 to 78 ohmmeters.

**Length** : 2PFA: 52 cm (20.5")

**Diameter** : 39mm (1.5")

**Pressure Rating**: 200 Bar (3000 PSI)

**Weight** : 1.4 Kg (3.1 lbs)

**Operating Temperature**: 80 C (176 F)

**Sensor**: 7-electrode mirrored Wenner array & fast-response semi-cond. for Temperature

**Accuracy** : Better than 1% both sensors

**Resolution**: FR: 0.05%. Temp.: 0.01 C

**Field Applications**: Temperature-Fluid Resistivity measurements are used in water quality studies, fracture characterization work, and geothermal gradient mapping.

COLOG A Division of Layne Christensen Company

810 QUAIL STREET, SUITE E • LAKEWOOD, COLORADO 80215 • PHONE 303/279-0171 • FAX 303/278-0135

# BT9601

## BT9601 DUAL VIEWING DOWNHOLE INSPECTION COLOR WITH ARTICULATING SIDE VIEW AND ADDITIONAL LED LIGHTING

**CAMERA SPECIFICATIONS:**

- NTSC Format
- Horizontal resolution of 480 TV lines
- Effective Picture Element 768(H) X 494(V)
- Hermetically sealed and charged with up to 15 psi of nitrogen gas
- 2.2 mm lens with a maximum field of view of 92.6 degrees
- Stainless steel watertight underwater housing
- Weight less than 19 lbs
- FSK/digital control technology
- Internal diagnostic check system with on-screen display
- Minimum illumination of 1 lux @ f1.2
- 3.5 inch maximum outside diameter
- 22 inches long
- Color Camera Module
- Maximum power consumption – 150Watts
- Pressure rated to 2,500 psi.

**COLOG** A Division of Layne Christensen Company

810 QUAIL STREET, SUITE E • LAKEWOOD, COLORADO 80215 • PHONE 303/279-0171 • FAX 303/278-0135

# BT12713

## Single Conductor Portable Camera Control Unit

BT12713 will control all CCV made cameras, as well as some competitors. Voltages range from 80 VDC to 200 VDC. The control unit will operate cameras through 1,500 feet of ¼ inch coaxial cable. The LCD meter will alert you to any impending communication problems. Additional video output and microphone is included. A built in fan helps cool the electronics. The additional on-screen counter module allows for a 1 pulse, 10 pulse, or a greater than 128 pulse per revolution 5 VDC encoder. All connection cables are included, as well as a CV93672 desktop control box.


**CONTROL UNIT FEATURES:**

1. Dual View or Single view camera operation
2. Dimensions: 10.5H X 10.5W X 17L
3. Economically priced
4. Electronically configured to operate up to 1500' of cable length
5. On-screen depth footage
6. Voice over recording (microphone)
7. Additional Video/Audio outputs available

Insert DVD of the 2012 downhole
video with hard copies.

## ATTACHMENT 5

2013 Geophysical Characterization

# ATTACHMENT 5-1

2013 Geophysical Logging Results

**Geophysical Logging Results**
**Rico-Argentine Mine Site**
**Dolores County, Colorado**

Prepared for
AMEC Environment & Infrastructure, Inc.
6 December 2013

Prepared by
Layne Christensen Company – Colog Division
810 Quail Street, Suite E, Lakewood, CO 80215
Phone: (303) 279-0171 Fax: (303) 278-0135

## I. Introduction

In accordance with the subcontract task order No.: C013100613, Project No.: SA11161313, Agreement No.: SD-0218-2011, Layne Christensen Company – Colog Division (Colog) provided services to acquire geophysical data in the 517 Shaft (mine shaft) at the Rico-Argentine Mine Site in Rico, Colorado (site). Services were performed during the time period from May 15 through June 18, 2013.

The 517 Shaft was found to be fully timbered and approximately seven feet by seven feet in area. The opening to the shaft was about 220 horizontal feet from the portal of the 517 Shaft Access Tunnel. The flooded section of the mine shaft was measured at a depth of approximately 453 feet below the shaft collar[1] (i.e. below ground surface) and continued to a total depth of 623 feet, as measured by a small diameter logging probe. Specific surveillance geophysical methods included the following:

- A water quality monitoring probe (Mount Sopris model 2ISA-1000) logged a vertical water quality profile and included: pH, temperature, conductivity, dissolved oxygen, and oxidation-reduction potential (ORP).

- A water quality monitoring device (In-Situ model TROLL 9500) was attached to the wireline above the Sonar head. This device logged a vertical water quality profile and included: pH, temperature, conductivity, and ORP.

- Vertical flow velocities in the flooded section were observed and recorded with a Corehole Dynamic Flowmeter probe. This probe was lowered to specific locations and apparent velocities were collected.

- Horizontal flow velocities in the flooded section were observed and recorded with a Colloidal Borescope Flowmeter probe. This probe was lowered to specific locations and apparent velocities and directions were collected.

- Discrete water samples were collected from several selected depths with an air-powered submersible pump (Bennett model 180-6). The pump was lowered to specific locations and water samples were collected from the outflow tube, at the surface. All tubing was purged, with the intake at the specified depth, before each sample.

- Acoustic imaging was performed with a horizontal scanning sonar head (Imagenex 881A). The sonar head was raised from the deepest accessible point, 537.2 feet, to the ambient fluid level, 453.4 feet, at a constant rate, while the head was rotating. Lower depths were not accessible by the sonar head due to collapsed timbers encountered within the mine shaft.

- A downhole video system was used to collect continuous real-time images within the 517 Shaft. As the camera was lowered downward, the collected image was toggled between axial and radial views. As the image was observed, the camera was stopped and controlled by a surface panel to capture 360° pan and tilt images as directed by an

[1] All depths presented herein are measured as feet below the 517 Shaft collar.

AMEC technical advisor. Depth encoding was continuously provided on the real time video image to 0.1 foot accuracy.

Colog provided two trained, experienced technicians, equipment, materials, and supplies necessary to complete the required services, including power supply, wireline, cabling, winches, monitors, compressor, tools, and spare parts.

In-mine support and communication were provided by personnel from the Colorado Division of Reclamation, Mining, and Safety (CDRMS). All on-site activities were carried out in level D personal protective equipment (PPE), with safety constraints following task specific health and safety plans (TSHASPs).


Geophysical logging trucks staged outside the 517 Shaft Access Tunnel portal.

Blaine Tunnel portal.

## II. Methodology

### A. Water Quality Probe

For measuring in-situ fluid properties, Colog utilized the Mount Sopris Instruments 2IFA-1000 water quality probe. The probe integrates the Ocean Seven 303 fluid sensor package, from Idronaut, in a $1^{5}/_{8}$ inch down-hole package that can communicate with the standard Mount Sopris Matrix and MGX-II logging platforms. Pressure, temperature, fluid electrical conductivity, pH, dissolved oxygen, and ORP measurements are made at frequent intervals, as small as 0.1 foot, as the probe is trolled slowly down through the fluid column. Salinity can be calculated according to the United Nations Educational, Scientific and Cultural Organization (UNESCO) Practical Salinity Scale of 1978, and dissolved oxygen concentrations can be calculated from oxygen percent using the UNESCO 1986 formula.

| Sensor Specifications: | | | |
|---|---|---|---|
| **Parameter** | **Range** | **Accuracy** | **Resolution** |
| Pressure | 0-1500 dbar | 0.25% FS | 0.1 dbar |
| Temperature | -1 - 49°C | 0.02°C | 0.004°C |
| Conductivity (Sea Wtr) | 0 – 62 mS/cm | 0.02 mS/cm | 0.004 mS/cm |
| Conductivity (Fr Wtr) | 0 – 6200 µS/cm | 2 µS/cm | 0.04 µS/cm |
| Oxygen | 0 50 ppm | 0.1 ppm | 0.01 ppm |
| pH | 0 – 14 pH | 0.05 | 0.01 |
| Redox | -1000 - +1000mV | 10 mV | 1mV |

Sensor Specifications for the Ocean Seven 303 sensor package.

Geothermal gradients in the near surface earth are usually dominated by conduction and are generally linearly increasing with depth due to the relative constancy of the thermal conductivity of earth materials. Convective heat flow within the mine shaft fluid is caused by fluid entering or leaving the mine shaft at an opening or some permeable interval. Therefore, deviations from the linear thermal gradient can be attributed to fluid movement. Both the thermal gradient and fluid conductivity profile of the mine shaft fluid can be obtained with the same probe. The temperature is measured with a thermistor and the fluid conductivity is measured with a closely spaced Wenner electrical array.

Slope changes in both the temperature and fluid conductivity logs may be indicative of fluid flow between the surrounding fluids (from the formation or mine tunnel intersections) and the mine shaft.

The fluid conductivity in the mine shaft is controlled primarily by the salinity. Therefore, salinity stratification, or the introduction of a fluid of different water quality into the mine shaft, can be observed by changes in the fluid conductivity log. Often, fluid exchange influences both the temperature and the fluid conductivity so that the response is evident in both logs.

Temperature corrected conductivity can be converted to equivalent NaCl salinity in parts per million (Bateman and Konen, 1977). A salinity profile can then be plotted to indicate the general water quality trend of the mine shaft fluid. Fundamental assumptions and limitations inherent in these procedures are as follows:

- The temperature log is usually the first log run and, unlike virtually all other logs, is run while the probe is moving downward. The exception to running this probe first, however, would be if any optical measurement is to be acquired. The idea is that the logging of the temperature/conductivity probe may stir up the fluids, inhibiting the optical device.

- The recorded mine shaft temperature is only that of the fluid surrounding the probe, which may or may not be representative of the temperature in the remainder of the mine shaft or connecting tunnels.

- Typically the geothermal gradient is considerably modified by fluid movement in the mine shaft and adjacent rocks.

### B. Troll 9500 Multiparameter Water Quality Instrument

A sub-two inch multiparameter water quality sonde (Troll 9500), manufactured by In-Situ, Inc, was used to collect duplicate measurements of mine shaft fluid conductivity, pH, temperature, and ORP. The ruggedized sensors utilize a wiper-free design to minimize effects in demanding environments such as high sediment loads and rapid flow rates. The sensors were factory calibrated prior to shipment and field calibrated prior to deployment.

Stabilization criteria were set for each measured parameter, and data were collected at a sample rate of 10 seconds. The Troll 9500 was attached to Colog's video cable above the camera in order to monitor conditions in the undisturbed water column within the 517 Shaft. As the video camera was lowered down the mine shaft, depth information was obtained through both the Troll 9500's pressure transducer probe and the video system's digital encoding system and time tagged to feet below water surface. After the completion of the initial video survey, the water quality parameter data were downloaded to a laptop computer and quality checked. These data are presented on the Geophysical Summary Plot (Attachment A) next to flow meter data.

The data collected in 2012, replotted to accurately indicate water surface depth, is included as Attachment B for reference. For a discussion of that data, please see the report provided in September 2012.

### C. Corehole Dynamic Flowmeter

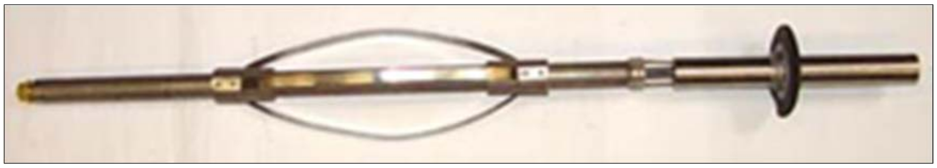
Colog's Corehole Dynamic Flowmeter (CDFM) is a high resolution device for measuring vertical fluid movement within a borehole. The flowmeter measures flow rates using the principal of Faraday's Law of Induction, and consists of a hollow cylinder housing an electromagnet and two electrodes, located 180 degrees apart and 90 degrees to the magnetic field. The voltage induced by a conductor (water), moving at right-angles through the magnetic field, is directly proportional to the velocity of the conductor.

The CDFM measures flow from 0.02 to 10 gallons per minute (gpm) (0.05 to 40 liters per minute) through the 0.91 inch diameter flow tube and standard multilayered flow diverter. Greater flow rates may be calculated by allowing a portion of the flow to move around the flowmeter or diverters, requiring estimates on the proportion of flow through, to flow around, the flowmeter, using known casing or corehole diameters.

The CDFM was run at discrete intervals within the mine shaft. Intervals were selected based upon a review of the measured water quality parameters (temperature, pH, conductivity, ORP and a video log). After a stabilization period of approximately five minutes, fluid velocity was measured at each station several times, until repeatable results were obtained.

A number of factors must be considered when interpreting high-resolution flow data including: 1) the effect of the irregular mine shaft on the flow regime, including adjoining tunnels and voids; 2) the effects of turbulent thermal convection and other secondary flow circulations; 3) real flow regimes are often changing with time as measurements are being made; and, 4) not all permeable intervals may be producing vertical flow under ambient conditions.

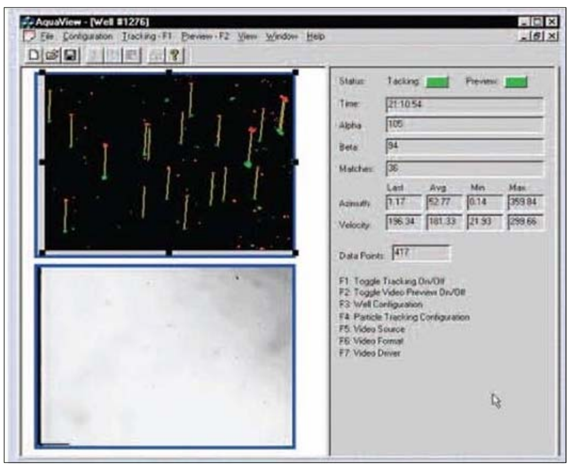
In a round well or borehole, some of these factors can be minimized by using a flow concentrating diverter and by locating the diverter in a portion of the borehole that is not fractured or rugose (by analyzing the caliper or a borehole imaging log). Due to the geometry of the mine shaft, though a diverter was used, most of the fluid movement within the shaft would have been around the CDFM. Efforts were made to suspend the CDFM in the center of the mine shaft, but the actual lateral placement of the CDFM could not be verified.



CDFM shown with flow diverters and centralizer.

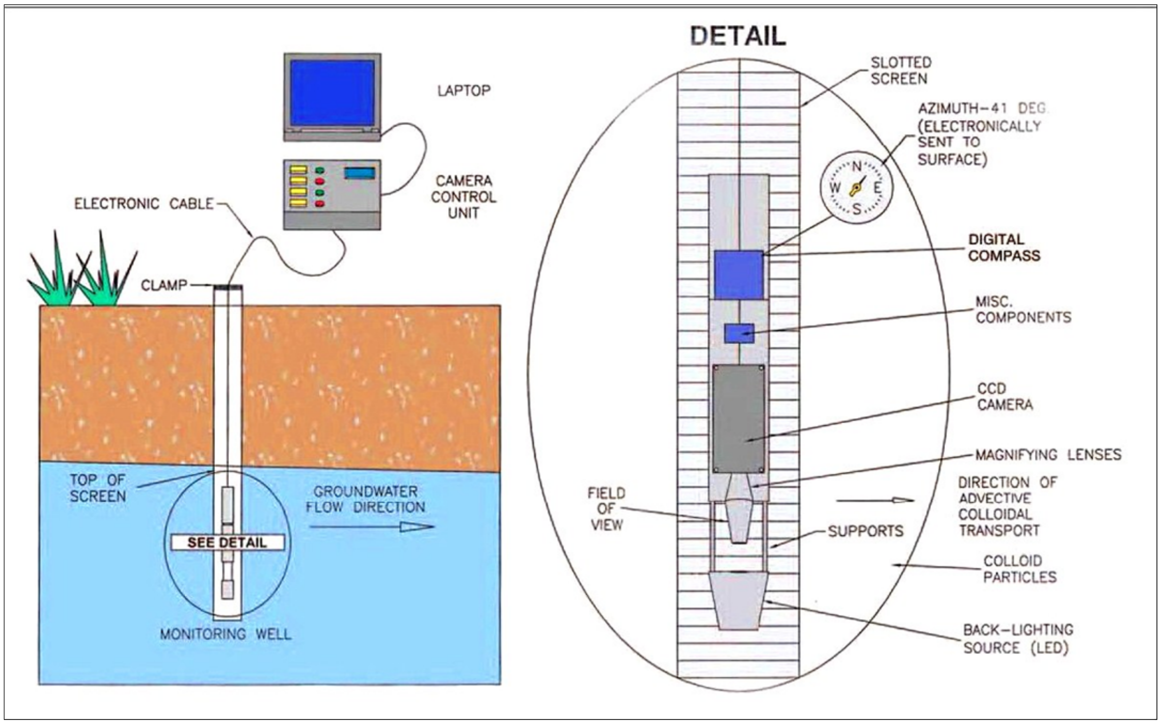
## D. Colloidal Borescope Flowmeter

Colog measured horizontal water velocity, direction, and particle size with the 1 ¾ inch AquaVision Colloidal Borescope Flowmeter System (CBFM). Using a downhole video microscope with a 2.7 Millimeter (mm) x 2.0 mm field of view, the CBFM yields thousands of data points per minute for statistically assured data. Particulates within the fluid are tracked with the AquaVision software, assessing the velocity of each particle, and assigning a direction based on the on-board magneto resistive digital compass. Horizontal flow can be measured to depths up to 1000 feet.

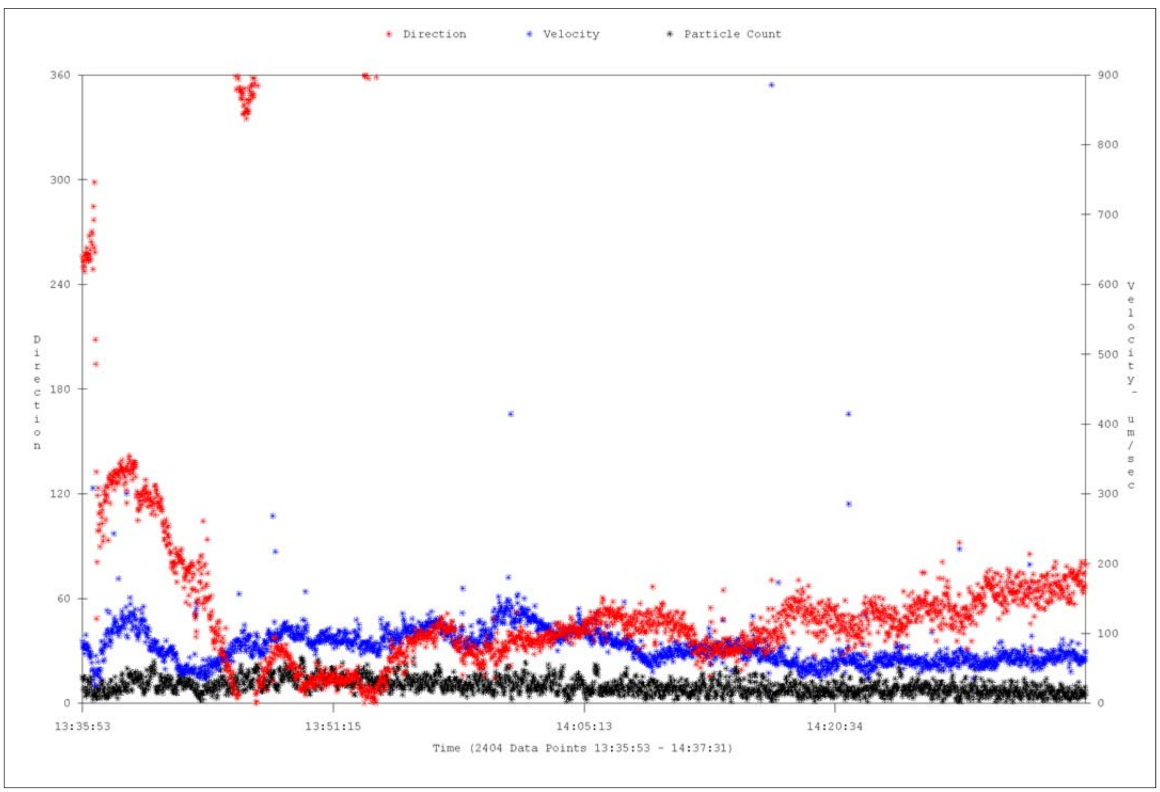




Screen shot of the Colloidal Borescope showing particles and particle tracking in real time.
System with the standard 200 foot cable reel. The optional 1000 foot cable was utilized in 517 Shaft.



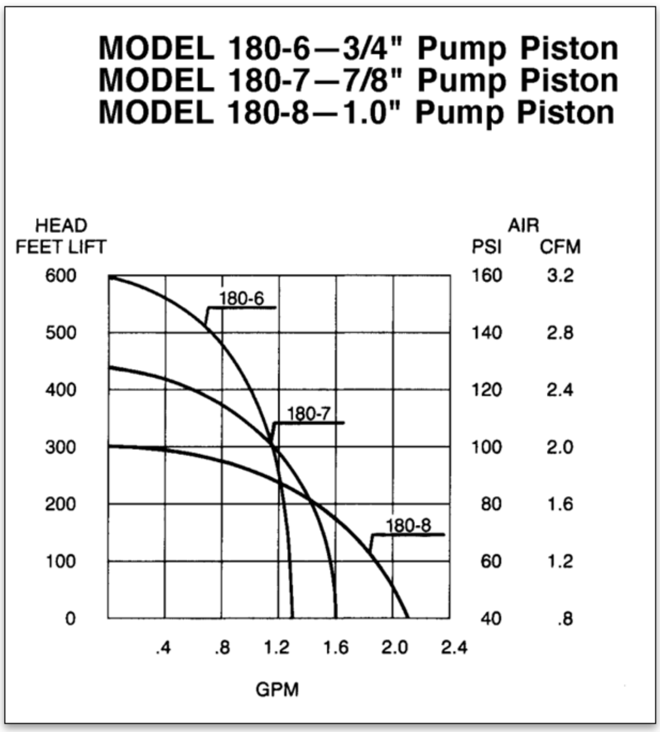

CBFM system set at a discrete testing location.



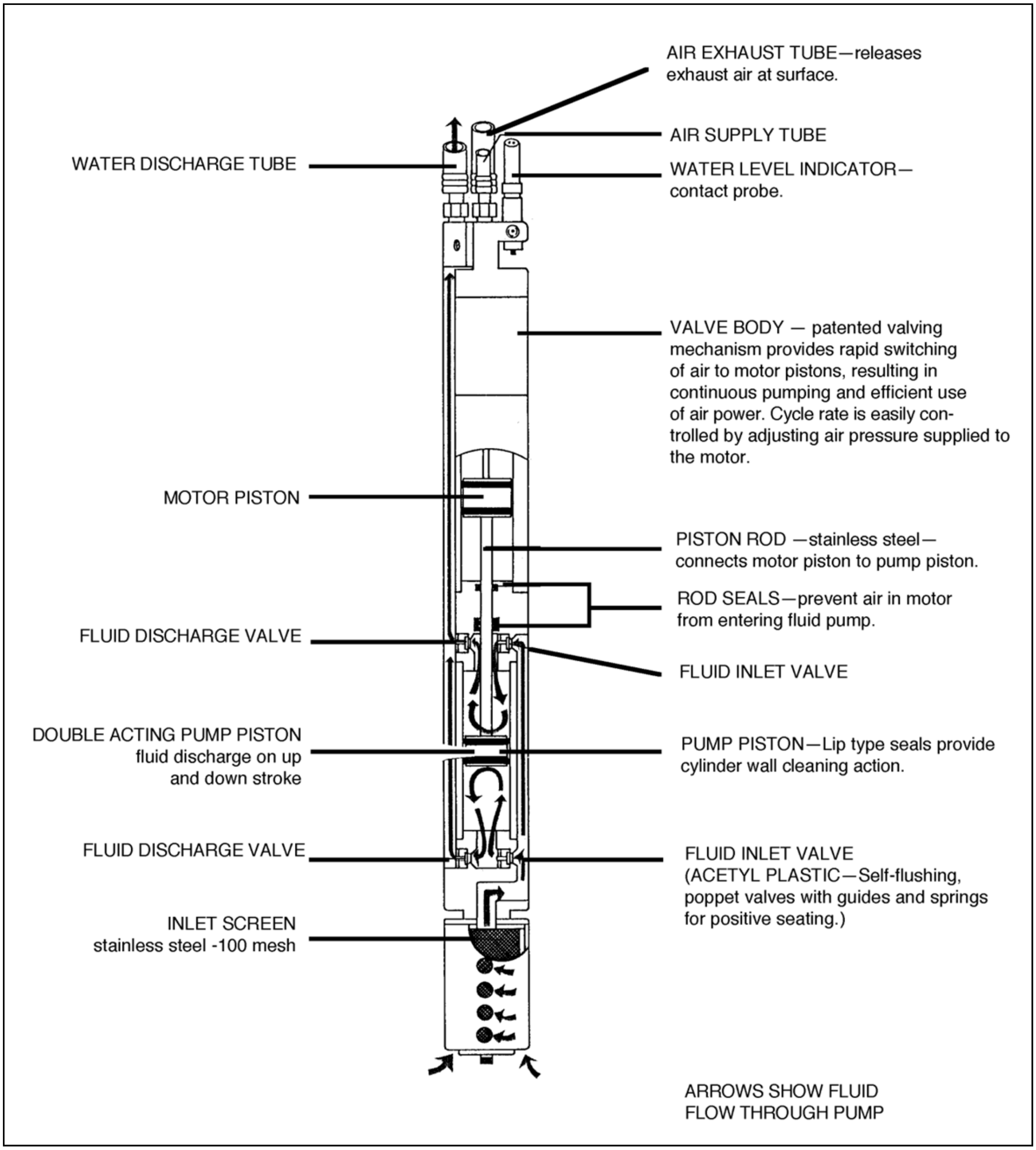

2,404 data points collected at an example testing location. The average direction (red) and velocity (blue) are calculated to provide statistically defensible values for this depth.

### E. Bennett Sample Pump

For fluid sampling at depth, Colog utilized the Bennett, model 180-6, air-driven, sample pump. The stainless steel pump has an automatic reciprocating piston motor, operated by compressed air that generates power for actuating a double-acting piston fluid pump. The ratio between the motor piston and the pump piston provides for significant lifts using relatively low pressure air from a small portable compressor. The pump discharge rate is controlled with an air pressure regulator. Exhaust air was vented into the fluid column. Prior to sampling at each station, five gallons of water were extracted from the station, approximately two tubing volumes, in order to purge the system of fluid from the previous station.




The ¾" pump piston allows 0.4 GPM lifts from as deep as 500 feet, utilizing a 150 pound per square inch (PSI), 3 cubic feet per minute (CFM) compressor. Higher flow rates may be achieved in lower head environments. Lower flow rates are controlled by reducing air pressure.




Bennett sample pump configured for submerged operation.

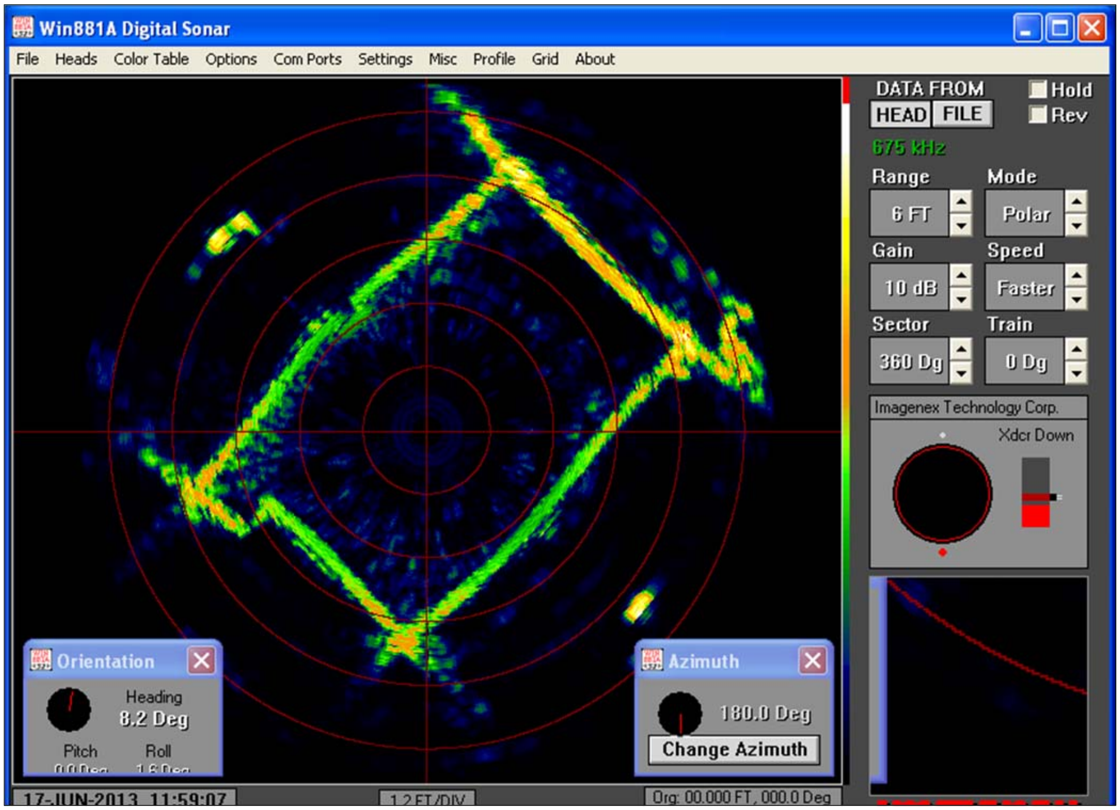
## F. Profiling Sonar

Multi-frequency profiling sonar surveys provide a unique means of imaging large, fluid-filled caverns and voids. Colog utilized the Imagenex Sonar Model 881A (sonar head) and adapted to a 4 conductor geophysical wireline.

The profiling sonar head is real-time configured through software, allowing a wide range of frequency selections and range resolutions.  The user has the ability to fine-tune the profiling configurations and adjust to customize for different field applications.

- Frequency: tunable from 600 kHZ to 1 MHZ in 5 kHz steps
- Transducer:  Fluid compensated profiling type
- Beam Width:
    - 600 kHz , 2.4º
    - 675 kHz, 2.1º
    - 1 MHz 1.4º
- Range Resolution:
    - 1 to 4 meters, 2mm (0.8”)
    - 5 meters and greater, 10mm (0.4”)
- Range Scales: 1m, 2m, 3m, 4m, 5m, 10m, 20m, 40m, 50m, 60m, 80m, 100m
- Horizontal Resolution:
    - 1200 samples per revolution (SPR), 0.3º increments
    - 600 SPR, 0.6º
    - 400 SPR, 0.9º
    - 300 SPR, 1.2º
    - 150 samples per revolution, 2.4 degree increments
- Vertical Resolution:  Dependant on void dimensions and beam width

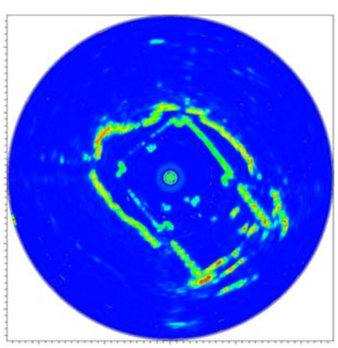
Two sets of data were collected, first at stationary intervals, or as a continuous profile while the sonar head was lowered into the 517 Shaft, and then continuously as the sonar head was extracted out of the mine shaft.  The continuous extraction rate was 0.5 foot per minute.




Screen capture of the sonar field data acquisition software – Win881A.exe.
This image is from the 517 Shaft at 451.0 feet below the top of the shaft.
The sonar head face is at the top of the image and is heading 8.2 degrees east of magnetic north.
Each division represents 1.2 feet from the center of the sonar head.

Sonar images are oriented by a 3-Axis Magnetometer and 3-Axis Accelerometer. Heading, Pitch, and Roll are displayed in the acquisition screen. These data are integrated into the binary data stream for post processing and image presentation.

In-house processing software (SonarSHED™) has been developed in order to create a platform to accommodate the 2- and 3-dimentional acoustical displays and virtual images. Data are processed and displayed in different views and color scale enhancements using Software VisIT™ provided by Lawrence Livermore National Laboratory.



| | | | | 17jun2013- |
|---|---|---|---|---|
| 17-JUN-2013 | 12:01:22.32 | 04.165 | 00.000 | 240.000 |
| 17-JUN-2013 | 12:01:22.37 | 04.021 | 00.000 | 241.200 |
| 17-JUN-2013 | 12:01:22.40 | 03.955 | 00.000 | 242.400 |
| 17-JUN-2013 | 12:01:22.45 | 03.988 | 00.000 | 243.600 |
| 17-JUN-2013 | 12:01:22.50 | 04.263 | 00.000 | 244.800 |
| 17-JUN-2013 | 12:01:22.54 | 03.942 | 00.000 | 246.000 |
| 17-JUN-2013 | 12:01:22.59 | 04.027 | 00.000 | 247.200 |
| 17-JUN-2013 | 12:01:22.64 | 03.981 | 00.000 | 248.400 |
| 17-JUN-2013 | 12:01:22.67 | 03.968 | 00.000 | 249.600 |
| 17-JUN-2013 | 12:01:22.71 | 04.060 | 00.000 | 250.800 |
| 17-JUN-2013 | 12:01:22.76 | 04.316 | 00.000 | 252.000 |
| 17-JUN-2013 | 12:01:22.81 | 04.158 | 00.000 | 253.200 |
| 17-JUN-2013 | 12:01:22.85 | 04.113 | 00.000 | 254.400 |
| 17-JUN-2013 | 12:01:22.89 | 04.119 | 00.000 | 255.600 |
| 17-JUN-2013 | 12:01:22.93 | 04.198 | 00.000 | 256.800 |
| 17-JUN-2013 | 12:01:22.98 | 04.172 | 00.000 | 258.000 |
| 17-JUN-2013 | 12:01:23.03 | 04.237 | 00.000 | 259.200 |
| 17-JUN-2013 | 12:01:23.09 | 04.132 | 00.000 | 260.400 |
| 17-JUN-2013 | 12:01:23.14 | 04.283 | 00.000 | 261.600 |
| 17-JUN-2013 | 12:01:23.17 | 04.067 | 00.000 | 262.800 |

Representative data from the 517 Shaft, in various stages of post-processing.

After sonar images from the 517 Shaft were post-processed, they were imported into WellCAD™ to compare with the other geophysical logs in order to compile a concise summary of all data.

### G. Downhole Video Survey

Colog provided a downhole video survey utilizing a system manufactured by Aries Industries Company. The BT9601 dual view downhole inspection camera contains an articulating side view with 360 degree rotation. The complete stand-alone system utilizes a BT12713 camera control box and is integrated with a ¼" diameter, coaxial, steel-armored, 1500 foot wireline, on a motorized winch.

Video surveys were recorded on HD/DVD format and viewed in real time as the color camera was lowered downward. As objects were observed the camera functionality allowed for still frame focusing, sideward viewing, rotation of side image, and light intensity adjustments.

The video image was limited by the capacity for artificial light illumination and by poor water clarity.

## III. Initial Interpretation

The fluid characterization probes were able to provide some information about the state of the water within the mine shaft. The flow measurements were only nominally quantifiable, as the water was not forced through the small inner diameter of the CDFM, but instead flowed past the CDFM within the large shaft cross-section. For rough estimate, the flow velocity (feet per minute) through the CDFM was assumed to match the flow velocity through the entire mine shaft, and the cross-section was assumed to be a constant seven feet by seven feet. However, we know the cross-section varies as the configuration of the timbers, stairs, and adjoining tunnels vary. The flow measurements do, however, demonstrate trends of flow direction and relative magnitude. Changes in flow direction and magnitude are indicative of inflow or outflow and are generally supported by anomalies in the fluid quality logs (Attachment A).

The CDFM data indicated downward flow at depths of 453 and 454 feet, the surface of the submerged portion of the mine shaft.[2] Below the near-surface water level, all measurements indicated upward flow. This evidence suggests that, at about 454.5 feet, most of the water exits the mine shaft. Variations in the upward flow velocity indicate inflows and outflows but should be considered with the knowledge that the shaft cross-sectional area is not truly constant. Water was found to flow up, from 522.5 feet (the deepest point accessed by the CDFM) to 507.5 feet at a relatively constant rate. The velocity decreased slightly for the 502.5 foot station, suggesting a relatively low outflow between these stations. This depth corresponded with an apparent void, indicated by the sonar survey; very little acoustic energy was returned to the sonar head at this depth. Similarly, a drop in the upward flow rate between the 497.5 foot and 492.5 foot stations suggested another outflow. The upward flow rate increased incrementally from 487.5 feet up to 472.5 feet, suggesting a source of inflow to the mine shaft. Substantial drops in the upward flow rates at 467.5 and 466 feet suggested some outflow in this region. Upward flow was variable up

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[2] Raw depth measurements varied somewhat by instrument and were corrected to the water surface depth during post-processing.

to 455 feet, but within a narrow range, not showing strong evidence for much inflow or outflow until about 454.5 feet.

At the depths where the CDFM suggested inflow or outflow, the CBFM was stationed to assess horizontal flow magnitude and direction. Directions are indicated on Attachment A, by the direction of the tadpole tail (north is up; azimuth values increase in a clockwise direction). Magnitudes are also notated on the plot. Horizontal flow was consistently measured toward the north to northeast, with a maximum velocity of 65.53 feet per day at 468.5 feet.

Additional depths were selected for fluid sampling. At each depth, after purging the sample line with multiple tubing volumes, samples were extracted from the mine shaft, with the Bennett sampling pump, and collected at the surface. These samples were submitted by AMEC to Pace Analytical Laboratories for analysis of total and dissolved metals and ions. Those data will be presented under separate cover. Water quality parameters, measured using a calibrated YSI 556 multi-probe system, connected to the sample tubing via a flow-through cell, are presented in the following table and are indicated on Attachment A.

| Location ID | Date | Time | Depth Below Shaft Collar | Sample ID | Purged Volume (L) | Temp.[1] (°C) | SEC[1] (uS/cm) | DO[1] (mg/L) | pH[1] (su) | ORP[1] (mV) | Comments |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 517 Shaft | 05/16/2013 | 12:10 | 463 | 517Shaft463130516 | 10.1 | 10.08 | 1,588 | 5.34 | 6.87 | 173.4 | Clear |
| | 05/16/2013 | 12:50 | 475 | 517Shaft475130516 | 19.7 | 10.20 | 1,598 | 5.51 | 6.90 | 171.2 | Clear, some particulate matter |
| | 05/17/2013 | 11:46 | 500 | 517Shaft500130517 | 36.0 | 12.04 | 1,595 | 5.57 | 6.90 | 184.2 | Clear, some particulate matter |
| | 05/17/2013 | 12:08 | 502 | not sampled | 14.0 | 12.33 | 1,596 | 5.51 | 6.94 | 178.0 | Particulate matter |
| | 05/17/2013 | 12:27 | 504 | not sampled | 17.8 | 12.36 | 1,595 | 5.92 | 6.96 | 178.7 | Particulate matter |
| | 05/17/2013 | 12:42 | 506 | not sampled | 15.8 | 12.75 | 1,595 | 6.01 | 6.98 | 182.2 | Particulate matter |
| | 05/17/2013 | 13:01 | 508 | not sampled | 19.0 | 12.87 | 1,596 | 6.22 | 6.97 | 181.4 | Yellowish particulate matter in water |
| | 05/17/2013 | 13:16 | 510 | not sampled | 16.6 | 13.07 | 1,595 | 6.48 | 6.99 | 182.3 | Yellowish particulate matter in water |
| | 05/17/2013 | 13:36 | 515 | not sampled | 18.8 | 13.20 | 1,597 | 6.62 | 6.91 | 186.7 | Yellowish particulate matter in water |
| | 05/17/2013 | 13:55 | 520 | 517Shaft520130517 | 18.4 | 13.15 | 1,597 | 6.72 | 6.97 | 192.4 | Yellow-orange water, floating particulate matter |

**Notes:**
1. Field water quality parameters measured with a calibrated YSI 556 multi-probe system.

**Abbreviations:**

| | |
|---|---|
| °C = degree Celsius | ORP = oxidation reduction potential |
| DO = dissolved oxygen | SEC = specific electrical conductance |
| L = liter | su = standard unit |
| mg/L = milligram per liter | uS/cm = microsiemen per centimeter |
| mV = millivolt | |

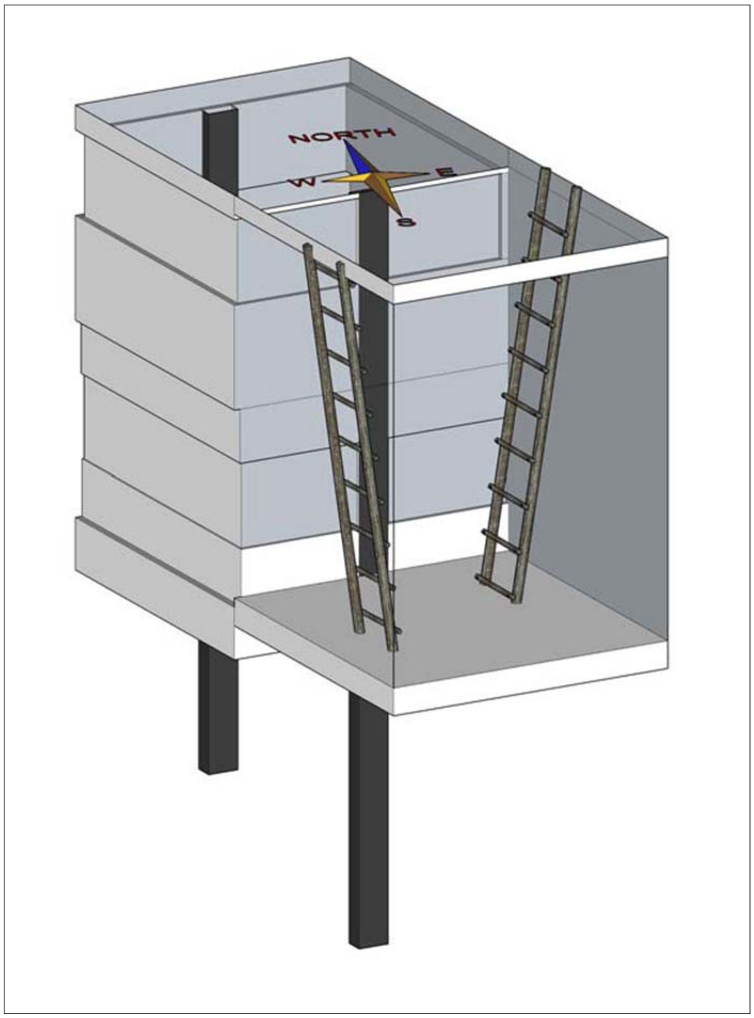
Sonar mapping indicated, in general, a shaft condition and shape consistent with what was observed in the video above fluid level.[3] A main shaft, constructed of vertical timbers, bound by a square frame of horizontal timbers, with vertical spacing of about one foot between each timber. Lift guides are observed in the center of the southeast and northwest sides. From the water surface to a depth 492 feet, sonar mapping indicated a secondary shaft outside the main shaft, on the southeast side. This secondary shaft was of similar size to the main shaft and divided into sections approximately seven feet tall, with a one foot separation between each section. The presence of the secondary shaft was consistent with the ladder access shaft observed above the

[3] Fluid level was established as 453.4 feet below the top of the mine shaft.

water level, in the video inspection.  The secondary shaft was not apparent below 494 feet, but the lift guides remained.

Below 494 feet, the timber pattern appeared to be more consistent rather than layered.  Large voids absorbed most of the acoustic signal from 503 to 506 feet, at 524 feet, from 525 to 527 feet, and below 536 feet.  The most pronounced constriction was observed at 523 feet on the northeast side of the main shaft.

Attachment C presents the first set of sonar plots at a depth scale matching the other geophysical logs (Attachment A).  The second plot (Attachment D) has an expanded scale to show detail.  In each presentation, the column title indicates which side of the 517 Shaft is being observed, from the outside, if the shaft were a solid body.  The following is a rendition of the basic shaft arrangement, based on observations from the video and sonar surveys.




Rendition of a length of the 517 Shaft, as imaged by the video and sonar inspections.

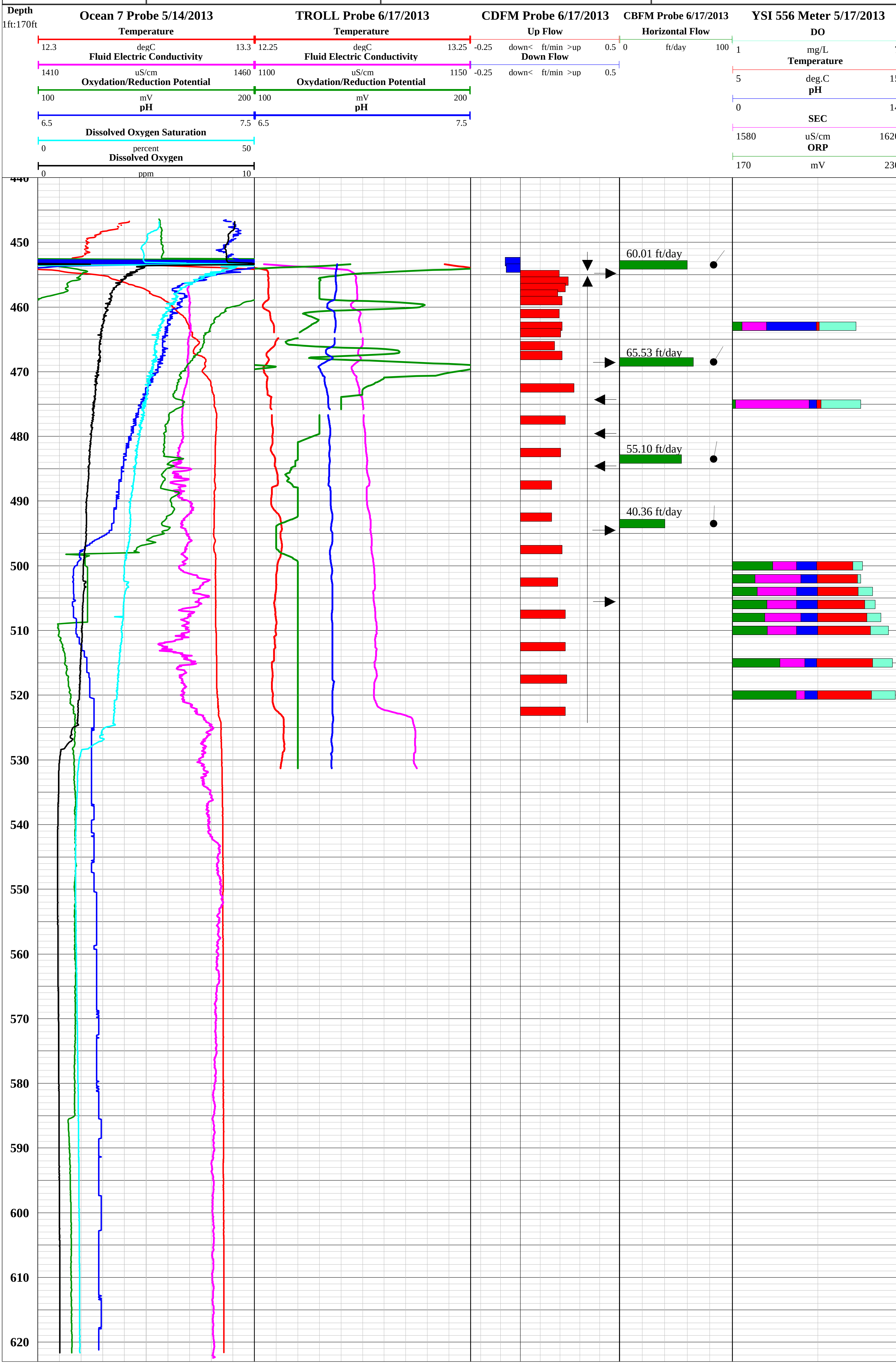
# ATTACHMENT A

## Geophysical Summary Plot

# Geophysical Summary Plot

COLOG Main Office
810 Quail Street, Suite E, Lakewood, CO 80215
Phone: (303) 279-0171, Fax: (303) 278-0135
www.colog.com

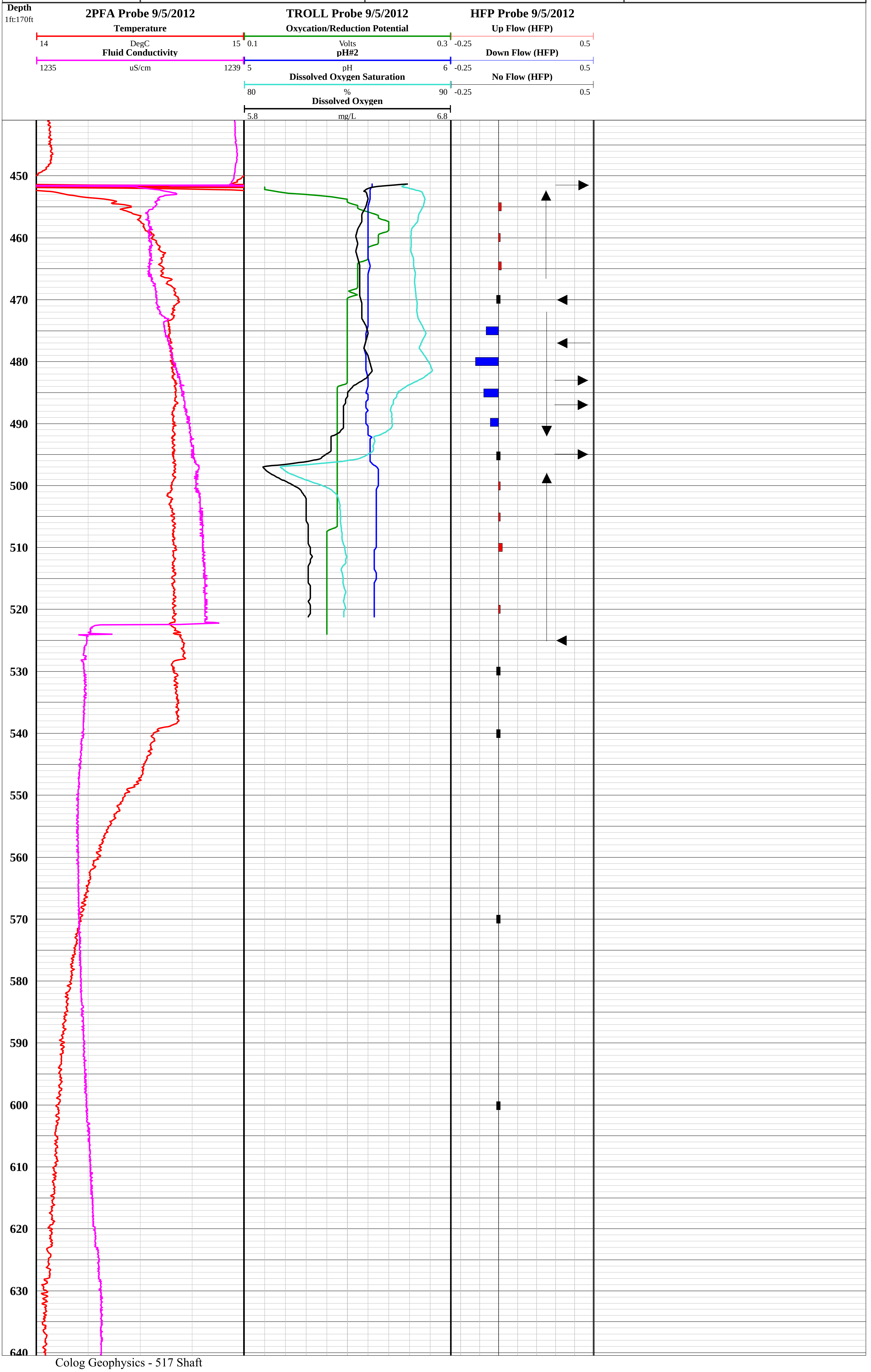
COMPANY: AMEC | PROJECT: Rico-Argentine Mine
DATE LOGGED: 5/14, 6/17 2013 | WELL: 517 Shaft



## ATTACHMENT B

## Geophysical Summary Plot – September 2012

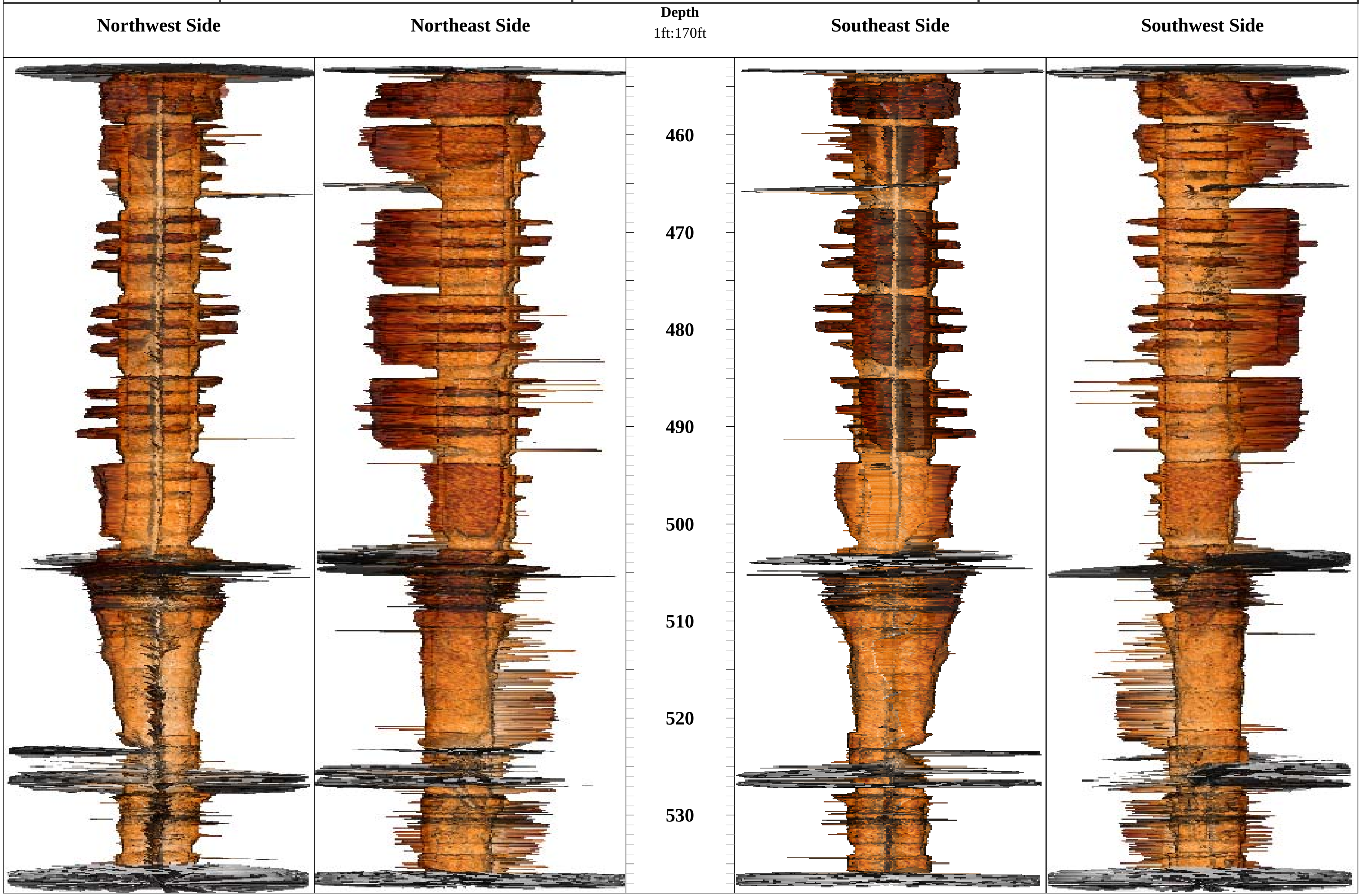
| COLOG | Geophysical Summary Plot | | COLOG Main Office |
|---|---|---|---|
| | COMPANY: AMEC | PROJECT: Rico-Argentine Mine | 810 Quail Street, Suite E, Lakewood, CO 80215 |
| | DATE LOGGED: 5 Sept. 2012 | WELL: 517 Shaft | Phone: (303) 279-0171, Fax: (303) 278-0135 |
| | | | www.colog.com |



## ATTACHMENT C

## Sonar Summary Plot – 1 foot:170 feet

| COLOG | Sonar Summary Plot | | COLOG Main Office |
|---|---|---|---|
| | COMPANY: AMEC | PROJECT: Rico-Argentine Mine | 810 Quail Street, Suite E, Lakewood, CO 80215 |
| | DATE LOGGED: 18 June 2013 | WELL: 517 Shaft | Phone: (303) 279-0171, Fax: (303) 278-0135 |
| | | | www.colog.com |



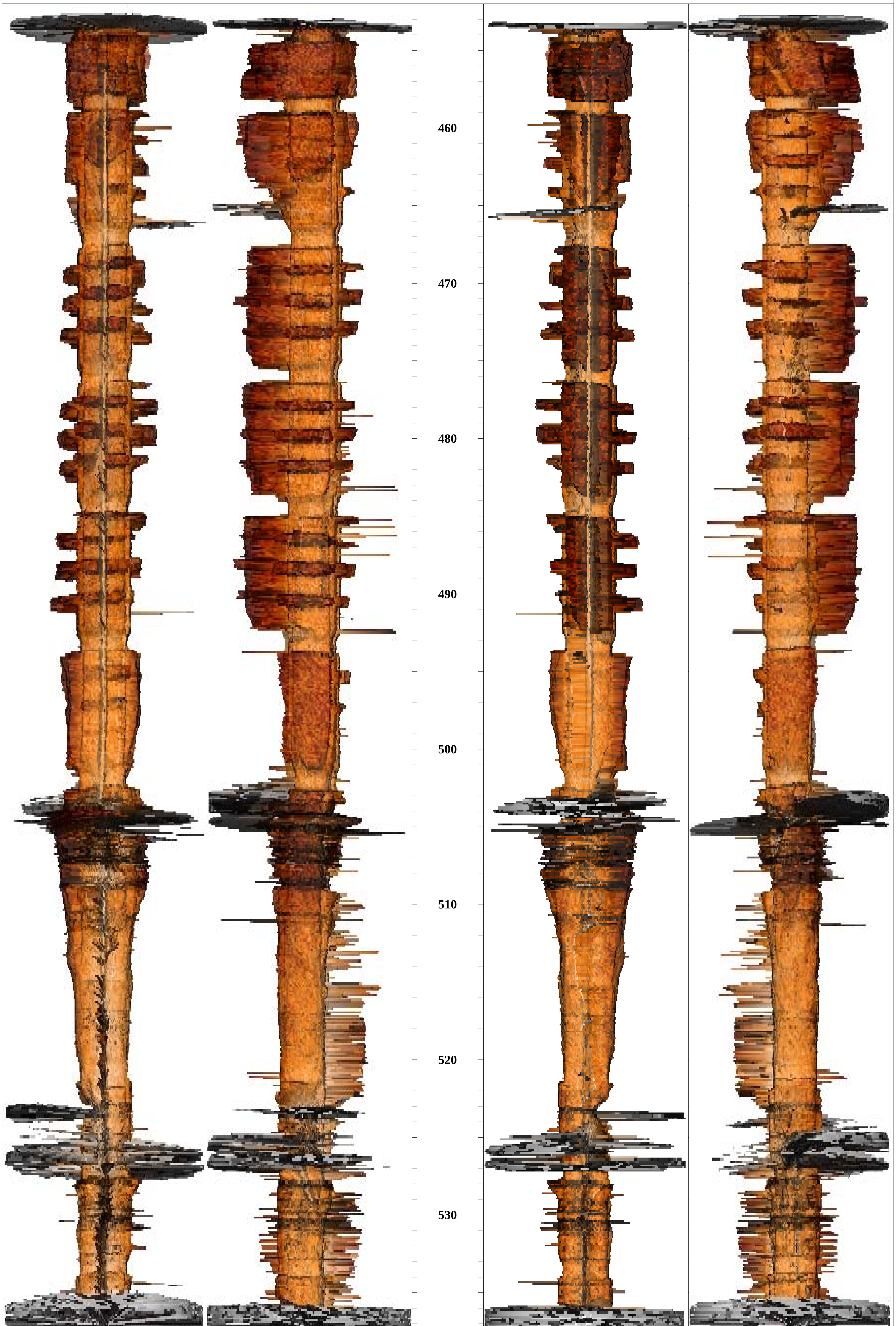
## ATTACHMENT D

## Sonar Summary Plot – 1 foot:70 feet

# Sonar Summary Plot

| | | |
|---|---|---|
| COMPANY: AMEC | PROJECT: Rico-Argentine Mine | **COLOG Main Office** |
| DATE LOGGED: 18 June 2013 | WELL: 517 Shaft | 810 Quail Street, Suite E, Lakewood, CO 80215<br>Phone: (303) 279-0171, Fax: (303) 278-0135<br>www.colog.com |

| Northwest Side | Northeast Side | Depth 1ft:70ft | Southeast Side | Southwest Side |
|---|---|---|---|---|



Insert DVD of the 2013 downhole
video with hard copies.

**ATTACHMENT 5-2**

517 Shaft Geophysical Characterization A-Frame Structure and Wireline

517 SHAFT GEOPHYSICAL CHARACTERIZATION
EVALUATION OF SOURCE WATER CONTROLS
Rico-Argentine Mine Site
Dolores County, Colorado


Wireline attached to the A-Frame structure above the 517 Shaft collar during 2013 geophysical characterization work.